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Journal
of the
American Ceramic Society
with
Ceramic Abstracts

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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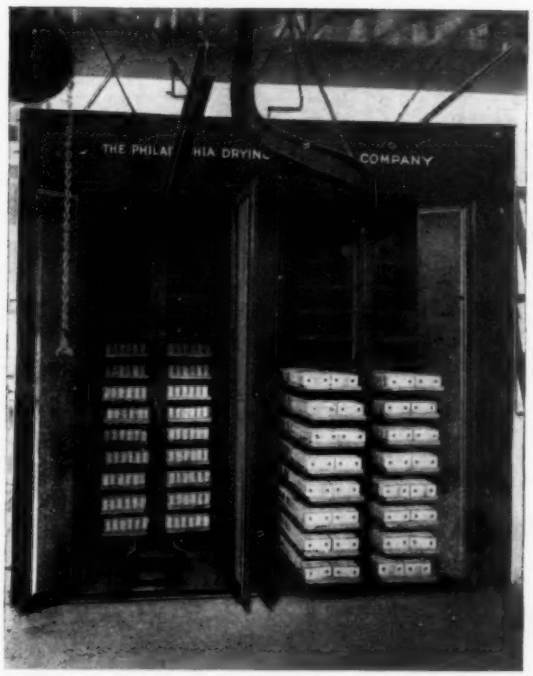
CERAMIC

CHEMICALS

MINERALS AND OXIDES

"HURRICANE" DRYERS



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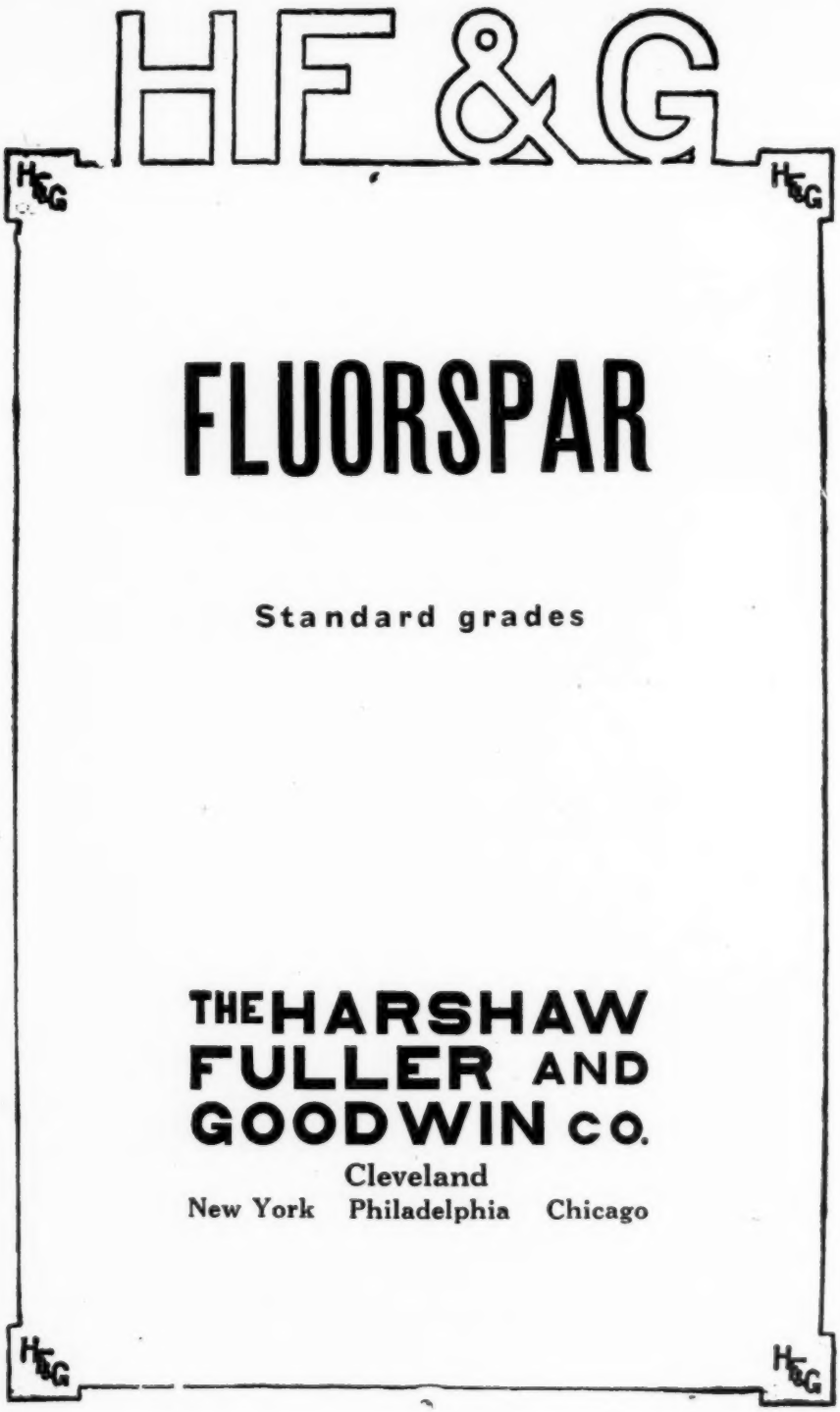

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JOURNAL
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AMERICAN CERAMIC SOCIETY

A monthly Journal devoted to the arts and sciences related to the silicate industries.

Editor: E. W. WASHBURN; Associate Editors: L. E. BARRINGER, A. V. BLEININGER, R. L. CLARE, E. P. POSTE, H. RIES, F. H. RHEAD, R. B. SOSMAN, R. T. STULL, E. W. TILLOTSON

Vol. 5 **February, 1922** **No. 2**

EDITORIALS

THE ART DIVISION OF THE AMERICAN CERAMIC SOCIETY

AN OUTLINE OF ITS ACTIVITIES: PRESENT PROGRAM AND FUTURE POSSIBILITIES

The Art Division, as its name implies is that Branch of the American Ceramic Society which devotes its activities and researches in the interest of the development of the artistic and decorative fields of ceramic work.

What These Activities Include.—Broadly speaking these activities include discussions, investigations and researches in connection with shape construction, ceramic draughtsmanship, design, decoration, modeling, ceramic sculpture, individual and commerical decorative processes, and the standardization of these in connection with the various types of ceramic wares. For instance, the technique and practical knowledge essential to whiteware practice is altogether different from that required in the manufacture of tile and architectural faience; and in connection with the various decorative processes, the successful execution of works in overglaze, underglaze on the clay or biscuit, stained clays and glazes, and with the mechanical processes, the problems surrounding each one of these are not only widely different in character, but they require a different technique and type of decoration.

The Relation of the Art Division to the Remainder of the A. C. S.—The Art Division is *not* a detached activity consisting of professional ceramic artists and decorators possessing little or no sympathy with allied technical and practical developments. As implied above, the active field is quite large, and it concerns not only the art worker, but the manufacturer and capitalist, the technical man, the practical potter, and finally the general public. Until the war period, ceramic developments in this country had not progressed on the same scale and with the same results as those of other countries. Our decorated wares with few exceptions could not compete with the productions of Europe and Japan. The artist and pottery decorator was merely a bench workman, and one of the lowest paid on the factory payroll. There was little or no competition with foreign concerns in those lines outside the general utilitarian wares made in the Trenton and East Liverpool districts. Consequently, except in those instances where definite technical requirements were essential to the successful marketing of the product (as is the case with chemical and electrical porcelain) there was no forced incentive to give serious consideration to those problems concerned with artistic excellence. But since the war the European and Asiatic countries have noted the potentialities of the American market to the extent that they are making strenuous efforts to capture this.

The foreign potter at present enjoys many advantages which we do not possess. Aside from traditional advantages, he is receiving valuable support from his respective government. He gives great attention to skill in potting. The foreign unions do not dominate labor to the extent that superior workmanship and facile production is discouraged. We do not have child labor in our potteries, and our scale of wages is much higher than is prevalent abroad. But one of the most vital conditions which the foreigner develops to the utmost extent and which we have to date not fully recognized is that concerned with artistic quality. The foreigner has government art and industrial schools. The young ceramic artist, designer and modeler must attend these schools in addition to serving his apprenticeship in the factories. The manufacturer himself is intensely interested in the schools, and in the decorative branches of his factories. He realizes that

in many cases it is the decoration that determines the sale of his product. The question of price is obviously a determining factor as is evidenced by our interest in the American Valuation Plan. But the American Valuation Plan alone, desirable as it is, will not give us the dominant position we should enjoy in our own country if our product is not as fine in quality, or as beautiful as the importations of our foreign competitors. It is the purpose of the Art Division with what help and influence it can obtain from the manufacturer and every other interest concerned, to work for conditions which will result in a better understanding of what is involved in the production of wares needing the services of the artist and craftsman, and to assist wherever it can to raise the standard of excellence.

The Present Personnel of the Art Division.—Of the charter members of this division, twelve are manufacturers and general managers of clayworking plants, nine are artists or decorators, nine are ceramic instructors, five are potters, and three are dealers in ceramic supplies. Since the division was formed practically every member of the A. C. S. who is engaged in ceramic art work is a member of the Art Division.

The Art Division has the interest and active support of the Organizing Secretary and the "Old Guard" including the progressive element in the parent organization. In fact, the organization of this division would have been impossible without this.

What the Art Division Has Done during the First Year of Its Existence.—1. Submitted outlines on organization and development in relation to art activities. The paper by Mr. L. V. Solon dealing with glaze and color development for decorative work is a most valuable contribution vitally concerning the technical man as well as the ceramic artist. The question of suitability and standardization of the ceramic color palette is a problem that varies according to the conditions involved, but it is a problem which must be solved if we are to obtain satisfactory results; and this is only one of many developments which cannot be attacked unless the technical man and the artist work together.

2. The officers of the division have inaugurated their membership campaign, and have compiled a list of over two thousand

names of prospective members. This list is not nearly complete but it embraces the names of individuals in the industrial and educational ceramic fields.

3. In addition to the usual organization communications, over one thousand letters and reports on Art Division activities have been sent out at no expense to the parent organization. These communications consist of letters to officials of other organizations in the interest of industrial schools, questionnaires, membership campaigns, letters to officials of the A. C. S. on reorganization matters, exibitions, etc.

4. The Art Division has advocated and succeeded in getting the Society to adopt the policy of holding exhibitions of ceramic work at the annual conventions and also at the Chemical Exposition in New York. This is an important innovation, and one that will do much to increase the influence of the Society.

5. In connection with the Society publication *The Journal* the Art Division is advocating a type of publication which will include matter of interest to the practical potter, decorator and student in ceramics.

The Present Program of the Art Division.—1. *The development activity* which most concerns not only the Art Division, but all those interested in the ceramic industry is the establishment of government industrial schools. The American Ceramic Society through the Art and Whiteware Divisions must exert every ininfluence to establish suitable schools in localities most in need of these. The only logical way to assist in bringing about such a condition is to formulate a tentative program covering such matters as organization, essential personnel, curriculum, locality, equipment and cost involved, and to present such data to the officials of the Society for further recommendations, and then to enlist the active interest of such bodies as the U. S. Potters' Association, the Associated Tile Manufacturers, the terra-cotta group, the various manufacturers outside these organizations, and the local bodies—the chambers of commerce and educational boards and every other means to attain the degree of publicity which will lead to direct action. The establishment of industrial art schools in districts like Zanesville, East Liverpool, Wheeling and other pottery centers will be a long step toward the realization of a

National Science and Art Department at least the equivalent of those functioning in the countries of our commercial rivals. The Art Division is working unceasingly to assist in bringing such a condition about.

2. *Research work in ceramic draughtsmanship*, ceramic shape construction, including working drawings for models, blocks and cases, and molds. Practically no attention is given to these activities, yet a reasonable amount of applied practical knowledge will result in vastly increased efficiency, a great saving in plaster and clay material, and better potting with decreased loss.

3. *Outlines for research work in mechanical and manual decorative processes.* The condition of "secrecy" which for so long surrounded the technical and practical potter still exists with the decorator. Many decorative specialists engaged in this country retain control of formulas and processes, many of which are not only old fashioned and obsolete, but which could be used to a desired degree of efficiency if these were properly chartered and subjected to competent direction and supervision.

It is part of the Art Division program to classify those decorative processes in present commercial use, giving formulas and methods, accompanied with illustrations of types in the various stages. This will eventually result in the standardization of the most generally used processes and open the field to many high class decorative artists who have heretofore been barred because of their lack of knowledge of the practical part of the work.

4. *Outlines for research work in the field of ceramic instruction.* Considerable work has already been done in connection with formulating practical courses suitable for school work. The result of this will be published in *The Journal* in the near future. Many educational forces are interested in the possibilities involved in ceramic art instruction, but too little is known of the requirements. It is part of the program of the Art Division to not only coöperate with those schools needing information and assistance, but to standardize those processes which are suitable for school work.

5. *Exhibitions and publicity.* The general public and even the artist himself is not so concerned about the technique and exposition and discussion of methods as he is about the finished result. No artist would gain a reputation by simply writing and talking

about his work. He must exhibit it. The same conditions govern any industrial activity and particularly that of the ceramist. As a national organization, attempting to cover the entire industrial and educational fields we would be seriously limiting our possibilities of expansion and consequent influence if we neglected the opportunity to exhibit ceramic wares either as concrete examples of some specific development or in connection with some standard of properties, quality, or production method. We would become an introverted organization possessing no interest to many allied activities. The exhibits at the annual conventions could properly be chiefly technical in character, but when the A. C. S. is represented in national expositions and exhibitions the exhibit should surely be as comprehensive as space will allow. Our organizationhas an opportunity to exhibit American ceramic works afforded by no other group of interests. Everyone familiar with national and international expositions knows the time and labor involved in visiting the various ceramic displays. The A. C. S. is in a position to arrange an exhibit which will include practically every type of product made in the country. The value of such an exhibit both to the ceramic student and to the potter is obvious and needs no further comment here. The Art Division is cooperating with the other divisions in the interest of such exhibitions. The A. C. S. will have exhibits at the coming convention in February and at the Chemical Exposition in New York in September. When the benefits derived from such action are definitely recognized steps will be taken to establish a permanent exhibit or museum in the headquarters of the society. This will afford the scientist, the practical potter and student opportunity to examine actual examples of every type of ceramic work.

6. *A. C. S. interest in American museums.* Everyone interested in historical pottery is aware of the fact that no technical or practical information is offered by museum authorities, or that no such information accompanies the historical data usually attached to each exhibit; nor is it published by the museum authorities in separate form. Yet such information contributed by authoritative sources would be of unquestioned value to the industrial concerns interested in such types. While it would no doubt be a difficult matter for an individual to be instrumental in cre-

ating such a condition, it is easily possible that the A. C. S. might be the determining factor which would result in the compilation of a technical catalogue for one of the larger museums. If such a course were followed there is little doubt that the other museums would adopt this practice. Incidentally, the museum authorities would be quick to see that this would lead to a greatly increased interest in the exhibits. The Art Division is taking steps to approach certain of the museums with a view of ascertaining the probability of undertaking such a work.

Advantages of Membership in the Art Division.—1. *The manufacturer will be in a much better position to standardize his decorative processes than he is at present.* He will be able to keep in close touch with current developments in ceramic decorations. He will be able to organize his decorative and practical research department on a practical paying basis; an activity which will be much more productive and much less expensive than the present prevalent nondescript experimenting by people who are not equipped either by training or experience to do research work.

2. *With the existence of a definite research and development program* suitable to the particular needs of the plant, the executives concerned will be relieved of spasmodic participation in experiments, a condition which will allow them to concentrate on routine productive work. By being members of the Art Division they will be acquainted with particulars and conditions involved in new developments, and they will in consequence be better equipped to take care of regular factory production.

3. *Dealers.* In connection with desirable specifications and satisfactory standards, the dealer is more competent to judge ceramic wares if he knows of what these specifications and standards consist. His interest in the Art Division would hasten a condition where these standards could be established and maintained.

4. *Architects.* The advantages of a membership to this class are much the same as those offered to dealers. Every architect interested in tile and terra cotta should be familiar with the practical possibilities and limitations of these products. Both from a decorative and a structural point of view, there is much information in connection with standards which can be obtained if enough interest and support is active in the Society.

5. *Technical men.* Every technical man employed by a concern producing artistic wares should know something of the processes in practice and under development. The article by Mr. Solon previously referred to is one contribution which closely concerns the coöperation necessary between the various activities. The technical man cannot work alone, neither can the artist, and none but the decorative specialist can judge of the artistic qualities of color and texture, or of the suitability of a particular process to a particular type of decoration. This does not mean that the decorator is likely to encroach in the legitimate activities of the technical man. It means that the work of the technician will be put to proper use and developed to the fullest extent. The Art Division has much to offer to the technical man who has the vision to see that the result of his labor is not adequately presented unless it is done with the recognition that it must meet the conditions essential to good decorative quality, and that he must work in harmony with the artist.

6. *The designer and decorator.* To the greatest extent the success of the Art Division depends upon the interest and coöperation of the decorative specialist. It is fortunate that the rapidly increasing requirements of the present day commercial market demand considerably more artistic knowledge and skill than has been prevalent or acceptable to this time. These market demands will be met irrespective of the attitude of the incompetent decorator, the bench hack, or the reactionary. Happily there is no dearth of talent in other decorative fields, and with the increasing possibilities and needs in ceramic work, this talent will be used, in fact is already being used to assist in the manufacture of higher types of artistic productions. As is the case with every other industrial activity the artist and decorator must keep step with the march of progress, or they must make room for those who are better prepared. The Art Division has not been formed for the exclusive benefit of the decorator. As stated, it is an industrial activity to function in the interest of the development of ceramic art. It is practically essential that the ceramic decorator join such a movement as this if he is to have an adequate understanding of the conditions involved.

7. *The pottery instructor, student and layman.* Enough has al-

ready been said in this statement to give a fairly comprehensive idea of the possibilities and opportunities in ceramic work open to those who are interested in following such a progressive movement as the one outlined. It affects everyone interested in ceramics. The greater the active interest the more comprehensive the actual results will be No one realizes the size of the program involved in the consideration of this crude outline more than those who are seriously and consistently planning and working it out to a definite successful result. But back of this realization is the knowledge of the great need for such an activity, a need which must be filled if we are to not merely compete in the world markets, but if we are successfully to hold our own in our own country.

FREDERICK H. RHEAD
Chairman Art Division

SEVEN CONVENTIONS IN ONE

Our Society has so increased its scope that the twenty-fourth annual meeting at St. Louis, Feb. 27th to March 3rd, inclusive, will actually be seven conventions in one. The seven divisions will meet separately except for two or three meetings of general interest and will make visits to the various plants separately. The list of papers to be presented, colloquiums to be held, and formal discussions on the program are so many and so varied that any one interested in any department in the Silicate Industries will find something especially arranged for him every hour of the five days.

Preliminary announcements have already been mailed to every member and the general program will reach each one before the Convention date.

One evening will be devoted to motion pictures and probably a theatre will be rented for the occasion. At this date (January 8th) five films are available: The Manufacture of Iron Sheets for Enameling; The Romance of Glass; The Manufacture of Face Brick; The Manufacture of Terra Cotta; and The Tale of the Tub, the latter showing the manufacture of porcelain and enameled bath tubs.

The subjects for forty-two papers are already in hand at this date and more than forty subjects for colloquiums and discussions are being considered.

To make it possible to have the maximum time for the technical program and plant visitations, the business session will be shortened, first by having all reports printed for distribution and not read, and second by having the inauguration of the officers at the banquet Tuesday night. There will be but one speaker at the banquet.

One evening, however, will be purely a social one and the old and well remembered SECTION Q gatherings will be emulated. This will be on Monday night and although called a Smoker, will be much more, ending with a dance. A surprise for each and all is in store.

The dates, February 27th to March 3rd inclusive. The place, St. Louis, Mo. Headquarters and meeting place for all sessions, the Hotel Statler. Make your reservations NOW.

The following members of the Papers and Program Committee each have charge of one of the Seven Conventions; ask them about the one in which you are particularly interested.

Terra Cotta Division. R. L. Clare, Federal Terra Cotta Co., Woodbridge, N. J.

Whitewares Division. C. C. Treischel, Gen. Elec. Co., Schenectady, N. Y.

Heavy Clay Products Division. C. Forest Teft, Watsontown, Pa.

Glass Division. Dr. E. Ward Tillotson, Mellon Inst., Pittsburgh, Pa.

Enamel Division. R. R. Danielson, Bureau of Standards, Washington, D. C.

Refractories Division. F. A. Harvey, U. S. Refractories Corp., Mt. Union, Pa.

Art Division. Miss Mabel C. Farren, 3600 Forbes St., Pittsburgh, Pa.

R. D. LANDRUM
Chairman

ORIGINAL PAPERS AND DISCUSSIONS

MOULDS FOR MAGNESITE, CHROME AND SILICA BRICK[1]

By Erling E. Ayars

ABSTRACT

Shrinkage.—Determination of allowance for shrinkage in mould manufacture is of prime importance. Design comes next.

Types of Moulds.—Slip moulds including the open slip and vent bottom types, steel slip liner moulds, and the wooden knock-down screw mould.

Materials Used.—Soft steel, cold rolled steel, galvanized iron and hard woods.

Moulding Tools.—The slicker, short scoop, smacker, putty knife, rammer and hammer.

Manufacture of Moulds.—Relation to the manufacture of all kinds of brick made from these special refractory materials. The treatment of each type of mould includes materials and method of manufacture, the materials and kinds of brick, the manufacture of which it is best suited, together with the manipulation best suited to turning out a uniformly good product. Correction of mould faults and suggestions for overcoming difficulties encountered in moulding brick find their place wherever the discussion of the various moulds and operations suggests any of the common troubles of the moulder.

Introduction

Moulds used in the manufacture of magnesite, chrome and silica refractories are divided roughly into three classes: slip moulds, slip-liner moulds and knock-down or screw moulds.

One of the first considerations in mould manufacture is to determine just how the brick is to be set when fired. Experience will indicate the position of setting most likely to produce the least strain under fire and the mould is designed accordingly.

In manufacturing moulds for magnesite and chrome brick it is necessary, as in the case of fire clay refractories, to allow for the shrinkage which occurs in burning. This amounts to approxi-

[1] Received Nov. 14, 1921.

mately one quarter inch to the foot, but varies with different classes of raw materials and should be determined for the raw material actually used. Magnesite and chrome brick tend to show undue shrinkage along the dimension perpendicular to the one on which they set while under fire. Chrome invariably behaves this way but there are classes of magnesite which do not exhibit this tendency to any appreciable extent. Experience is the only safe guide to follow. To offset this extra shrinkage due entirely to the weight of the brick itself, it is necessary to add, over and above the normal allowance of $^1/_4$ inch to the foot, approximately $^1/_8$ inch to 12 inch dimensions, $^3/_8$ to 15 inch dimensions and $^1/_4$ to 18 inch dimensions. No extra allowances are necessary on the other dimensions of the brick in this case. The importance of determining the setting influence before the mould is made is evident.

Moulds for silica brick are made with three different allowances for expansion in burning. Generally speaking, dimensions under 6 inches are allowed $^1/_8$ of an inch to the foot, over 6 inches and under 12 inches, $^1/_4$ inch to the foot, and over 12 inches, $^3/_8$ of an inch to the foot. The usual practice allows $^3/_8$ of an inch to the foot for length, $^1/_4$ inch for width and $^1/_8$ inch for depth. In dealing with large silica brick such as coke oven shapes, it is necessary to make even greater allowances for expansion than those mentioned, sometimes as high as $^1/_2$ inch to the foot. The variation in expansion of silica brick seems to be directly related to the mass represented and no definite rule can be given for any one material. The weight of individual pieces or of an entire bench as set in the kiln does not seem to affect the amount of expansion in a brick, provided of course the same heat treatment is extended to all.

Shrinkage and expansion rules may be obtained from any manufacturer of rules and are best made of spring steel. Wear on such rules is negligible and they do not bend like brass from which rules are occasionally made. When using three different rules as in silica mould manufacture, it is well to have different standardized gauges and widths for each rule, to avoid confusion and loss of time in handling.

In mould manufacture there are several things to consider in choosing the type of mould to be used. Among the first is the

ultimate cost of the mould. This must include first cost of material and labor in constructing the mould and repairs, which may be excessive in certain types of moulds.

Quantity and quality production after the mould goes into service is a big item and must be considered. With some moulds quantity production is impossible if quality is to be maintained. The same brick may be turned out in good quantity with equal quality from a mould of different design and construction.

The number of brick which are to be made must be considered also. An expensive mould should not be used for the manufacture of a few pieces if it can be avoided. In general the cheapest mould which will give the largest output and best quality should be made in all cases. Very often the most expensive mould from the standpoint of first cost is the cheapest in the long run. The mould maker must have a fund of experience to draw from and make his decisions in the light of past practice. Good moulds are the first step to a uniformly good product.

Slip Moulds

Slip moulds, employed almost entirely in silica brick manufacture, are of two kinds. First, the open-slip mould which is made in a gang of from four to six moulds and used with a slop mud only. The maximum size of brick to be made in this type of mould is limited to those which may be filled by the roll of one "Walk." Standard 9 inch sizes and similar brick are as large as one may expect to get good results with. Some manufacturers make 12 and $13^1/_2$ inch standard sizes and brick of similar dimensions in gang moulds of this type, but better quality can be obtained in this range of sizes by making a hammered brick, in which case the second kind or vent-bottom slip mould is used, and stiff mud employed.

To construct a gang mould of the open-slip type, $^3/_8$ inch soft steel is generally used (Fig. 1). The length of the gang is the combined width of the number of brick to be made plus allowance for thickness of the webs, with sufficient stock at both ends for hand holds. The width is determined by the length of the brick itself, and the depth in the same manner. Brick not exceeding

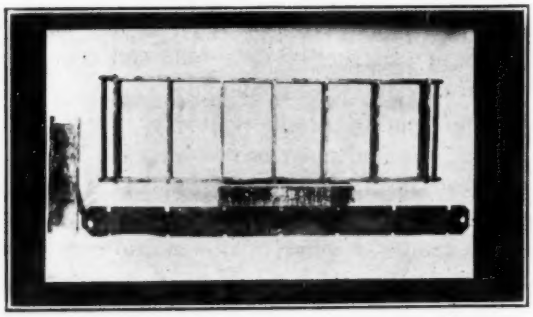

FIG. 1.—Showing the construction of the open-slip mould, the slotted side piece with holes drilled for hand holds, a web, and a complete mould.

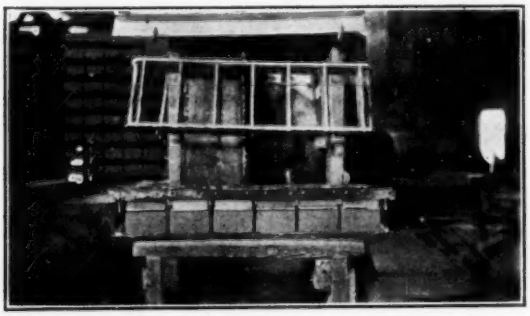

FIG. 2.—Showing a push board resting on a pallet of brick. The mould which has been dumped is seen in the rack above. Notice the slots in the push board into which the webs of the mould fit as it is lifted clear of the brick.

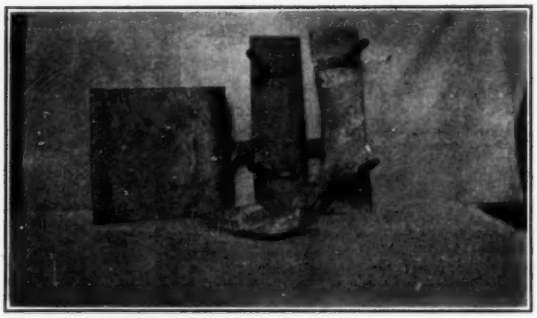

FIG. 3.—A "smacker," the "short scoop" and two "slickers," one of which has long since ceased to be useful.

$2^1/_2$ inches in thickness are made in this type of mould. Steel $2^3/_4$ inches wide is used in making moulds for $2^1/_2$ inch brick to give a little stock to dress on, so that the top and bottom of the mould may be exactly parallel. The same plan is followed in making moulds of any depth.

The side pieces are slotted top and bottom at the proper interval, and the webs, with projections to correspond, are fitted into the slots and riveted in place. Great care is necessary in laying off the position for the webs and good workmanship is essential, that the mould may be square and all webs perpendicular to the plane of the top and bottom when the whole is assembled. The side pieces project at each end about $2^1/_2$ inches beyond the outside webs in order to provide hand holds. These are made of $^1/_2$ to $^3/_4$ inch steel rods riveted through the side pieces and add rigidity to the mould.

The bottom of this mould consists of a flat steel plate $^1/_2$ inch thick, not fastened to the mould, but hinged to a heavier plate which is securely fastened to the moulding table. The bottom plate has a margin outside the mould of one inch on each side and 2 or 3 inches on each end. Four pins are placed in the top of this plate so as to fit into the exterior interior corners of the mould and secure it while the moulds are being filled and struck off. As soon as the brick are struck off, a pallet is inverted on top the mould. A rack, hinged to the moulding table, facilitates turning the mould and its contents over onto the pallet. The bottom is returned to the flat position, another mould laid on and filled, etc. A push board applied to the bottom of the inverted mould exerts a pressure against the brick as the mould is pulled off and prevents the deformation which occurs if the mould is lifted directly off the brick (Fig. 2).

Moulding Tools

Moulder's tools and their use will now be described. The slicker or striker is made of hard flat steel $^3/_8$ by 5 inches. The length varies according to the work in hand but is usually from 15 to 18 inches. The tool is provided with two handles at convenient intervals having a suitable angle with the working face.

The working or cutting edge is beveled back about $^1/_2$ inch on the bottom side. The slicker is used with all types of moulds and all types of products.

In manufacturing silica brick in vent-bottom, slip liner and screw moulds, the material is scooped into the moulds, rammed down into the corners with the short scoop handle, filled heaping full and pounded down hard with a "smacker," struck off with a slicker and dumped onto the pallet. The "smacker" is made of any wood which does not split easily and should not be less than $1^1/_4$ inch thick. The size varies with the mould it is to be used with. Ordinarily "smackers" are not as long as the mould but should be equally wide. One face is covered with $^1/_8$ inch flat iron and the handle is fastened to the other face. To guard against splitting, two slats are fitted to the back at either side of the handle, the grain crossing the grain of the large piece. All parts are fastened together with stove bolts (Fig. 3).

In moulding magnesite and chrome, the mould is partially filled with material which is rammed down hard into the corners and edges with a small steel rammer. This is then loosened on the top surface with a scratcher or fork. More material is piled in and heaped above the mould top. A large wooden hammer is used to pound it solidly into the mould, after which it is struck off and the brick dumped onto the pallet (Fig. 4).

Vent-Bottom Slip Moulds

Vent-bottom slip moulds are used exclusively in silica brick manufacture. The mould is made in practically the same manner as the open-slip mould previously described except that it is furnished with a solid bottom. Various designs may be used based on the desired arrangement of the brick as they lie on the pallet, and on the size of the brick to be made. The size of pallet available is generally the determining factor. For instance, a two-brick mould only can be used with a 12 x 9 x 3 brick and standard 9 inch pallets, while a 14 inch pallet will permit the use of a three-brick mould. The several styles of vent-bottom moulds shown illustrate the possibilities in construction (Figs. 5*a*, 6*a*).

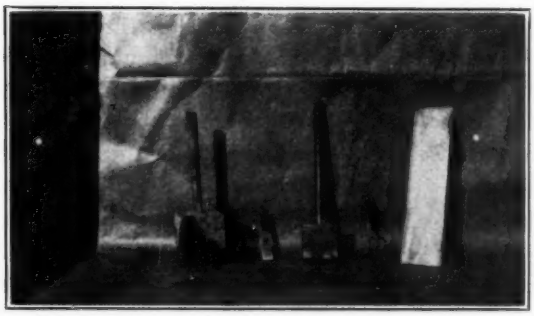

FIG. 4.—The "rammer," "fork, hammer, and slicker" used in the moulding of magnesite and chrome brick. The putty knife is used for cleaning the mould.

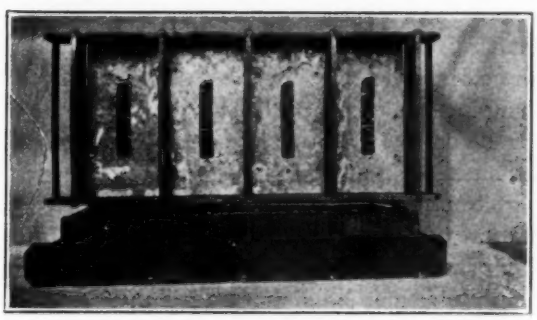

FIG. 5.—(*a*) Type of vent bottom mould used with 14" pallets, showing top and side view.
(*b*) Notice the thickness of the bottoms, the galvanized iron lining of the bottom and the vents. The webs are seen to extend below the top surface of the bottoms.

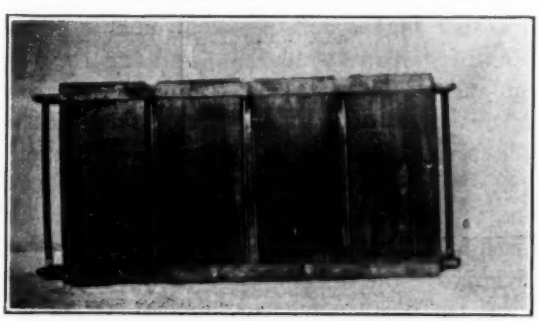

FIG 6.—(*a*) A back view of the mould shown in Fig. 5.
(*b*) Notice the vents, the strap iron binding and the beveled wooden bottom adjacent to the vents.

On account of the working principle of the mould a 4 inch depth appears to be the practical upper limit and this is attainable only in case the width is about the same or does not exceed six inches. The standard 12 and $13^1/_2$ inch sizes with depths of 2, $2^1/_2$ and 3 inches are all easily made in these moulds, as are also 9 inch sizes.

Bottoms for these moulds are made of $1^1/_2$ inch maple lined with 16 gauge galvanized iron. A small vent from $^1/_{16}$ to $^1/_8$ inch wide is left between the side of the mould and the bottom for the admission of air when the mould is turned for dumping thus allowing the brick to slip easily from the mould. The width of the vent depends both on the depth of the mould and the area of the mould bottom. Brick with a large area require a larger vent than those of smaller area since, on account of the soft condition of the brick the sides and ends have a tendency to lag behind the center in dumping, which results in a poor product. The vents are always made on the two longest sides of the brick. Needless, to say, they must be kept open by regular cleanings. A putty knife is generally used for this purpose (Fig 5*b*).

It is important that the sides or webs of the mould forming one side of the vent shall extend below the upper surface of the bottom about $^1/_4$ inch. This method of construction has two advantages. If the bottom of the side piece is on a level with the top plane of the mould bottom, more or less of the brick mixture will be forced out through the vent in pounding. This forms a fin which breaks off when the brick is dumped, leaving a rough rounded edge. The purpose of the vent is defeated as soon as it becomes filled with brick mixture, as in this case. Grains of rock are forced into the vent and wedging there are difficult to extract. Such a vent will wear rapidly and soon become too large to give even passably good results and the brick turned out will have widely rounded edges. By extending the side pieces below the top plane of the bottom, these faults are prevented and the result is a brick with sharp, well-formed edges of proper density.

To further improve the working qualities of the vent, it is desirable to bevel the wooden bottom back from the vent. This seems to admit more air and increases the speed and force of its entry.

After the bottom boards are secured in their proper places by means of stove bolts which are tapped into the ends of each mould box, the bottom is ironed with $^1/_8$ by 1 inch strap iron. These straps, secured with wood screws, cross the ends of the bottom boards and afford both resistance to wear and added strength to the mould (Fig. 6*b*).

Steel Slip Liner Moulds

Slip-liner moulds are used either in magnesite, chrome or silica manufacture and are made wholly or in part of steel. The mould box is usually made of $^3/_8$ inch soft steel which can be obtained in almost any desired width. The best method of making these boxes is as follows: The end pieces are cut to the proper inside dimension, measuring through the center. Projections at top and bottom are left which fit into slots in the side pieces, much on the order of a mortise and tenon joint. These projections on the end pieces extend beyond the thickness of the side piece far enough to allow for upsetting. Needless to say the slots and projections must be fitted accurately and an easy-driving fit is desirable. The slotting is accurately done on a shaper or planer. The side pieces are longer at each end, by $1^1/_2$ to 2 inches, than the mould box proper. Pieces of $^1/_2$ to $^3/_4$ inch round steel for hand holes are fitted into holes in both sides and riveted in place. These should be closely fitted and riveted in order to add to the strength of the mould box (Figs. 7, 8).

A good bottom is very important if the mould is to give satisfaction. The full steel bottom is most desirable and is made of $^3/_8$ inch soft steel. It should be of one piece, no matter how wide. On account of the vibration incident to moulding, a 2 piece bottom will not give good results. The sides and ends of the mould box are slotted with a $^3/_8$ groove allowing a margin along the lower edge, of from $^1/_4$ to $^1/_2$ inch, into which the bottom must be fitted before it is riveted together. It should be fitted with such accuracy that the box is absolutely true and tight. Good workmanship is most essential. With long moulds it is necessary to take account of the spring of the sides and bottom which is an inevitable result of the pounding during the manufacture of the brick. With the steel-bottom mould a wider margin is left when the grooves

FIG. 7.—Simple types of the slip-liner mould having plain sides and bottoms only.

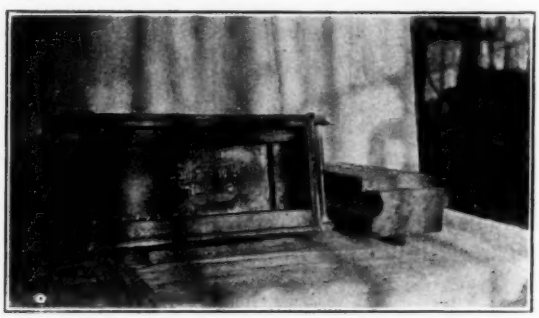

FIG. 8.—A mould illustrating the use of the tongue and groove as applied to making of liners. Notice also the irregularity in the nature of a step at one end of the bottom.

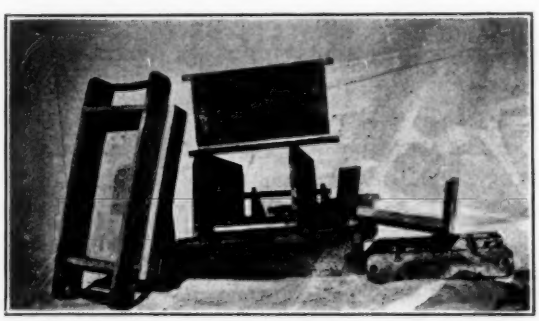

FIG. 9.—In the center of this figure we have an illustration of the best type of mould bottom. Note the slot near the bottom of the side pieces and also in the end piece resting on top of these side pieces. A piece of flat steel was placed in the slots of the side pieces to hold them in position and simulate a bottom. At the right the second method of bottom described is illustrated. Note the square shoulders riveted to the side pieces, the bottom being riveted to the shoulders. At the left is shown a wooden bottom lined with galvanized iron.

are cut in the sides and ends, and one or two $^3/_8$ steel rods are fitted into holes in the sides under the bottom and riveted in place after the bottom is put in. This keeps the sides from spreading appreciably and reduces the amount of spring in the bottom (Fig. 9).

A method used extensively in manufacturing bottoms for this type of mould requires a shoulder of $^1/_2$ inch square steel riveted to the sides and ends of the mould box on which the bottom rests. The bottom in turn is riveted to the shoulder. This type of mould bottom requires more material and labor and has perhaps less strength than the one previously described.

Another method of making the bottom which is very satisfactory for narrow moulds only, is to put on a wooden bottom lined with galvanized iron. Only well-seasoned hard wood should be used. Maple from $1^1/_2$ to 2 inches thick is the most satisfactory. After the mould box is put together the maple is cut to leave a $^1/_2$ inch margin all around the outside of the box. The lining of 16 gauge galvanized iron is fastened to the wood with small flat-head screws countersunk slightly below the surface of the iron. These screw heads are covered with a hard solder to make a smooth surface. The bottom is then fastened to the mould box with suitable stove bolts or machine screws tapped into the steel sides and ends. The heads should be countersunk into the wood and drawn up tightly against washers. When the bottom has been applied three straps of $^3/_8$ by $1^1/_2$ inch soft steel are fitted across the ends and middle of the bottom by gouging grooves $^1/_4$ by $1^1/_2$ inch into which the straps are fastened. Flat headed wood screws are used and the heads countersunk below the surface of the steel. These straps reduce the possibility of warping of the wooden bottom and resist wear when the mould is put into service. If no straps are used, the sides and ends of the wood wear off rapidly and the mould begins to rock back and forward as the brick is made. Imperfect brick are sometimes traceable to this fault. The full flat bearing which the straps give is essential for satisfactory mould service.

The liners are the next consideration in building the mould, although the proper form and dimensions of these should be figured out in advance so that the dimensions and form of the mould

box may be determined. It is always advisable to make a sketch of the entire mould with dimensions, which have been carefully checked against the dimensions of the finished product, using a shrinkage rule in the case of magnesite and chrome brick and expansion rules in the case of silica brick. Liners for plain rectangular brick are made from $^3/_8$ soft steel. Liners for brick having tongues and grooves must be proportionately thicker to take care of this irregularity in shape, or tongues and irregular shaped blocks can be riveted to the liners. It is advisable to use flat steel which is a little wider than the mould depth so that a few cuts may be taken on each edge to insure even bearings of the liner against the bottom of the box and regular depth throughout the length and breadth of the mould (Fig. 10).

There are several methods of joining the liners at the corners. The simplest method is probably the best, and consists merely of butting the end of each liner against the face of the one preceding it. This type of joint must be made true. It is easily cleaned and refitted. The miter joint, which is used to some extent, is harder to keep clean and refit and unless the dimensions of the liners are absolutely true to the dimensions of the mould box, the joint may spread, ever so slightly, leaving a featheredge at the corners of the brick. Cracks are a common result of this featheredge. Occasionally one may use a modified interlocking form of the first joint. This is hardest of all to keep clean and refit and is not considered a good joint on that account. Joints of any type, other than the first one mentioned, add more or less to the cost of the mould without improving its working qualities measurably and very often reduce the daily output of brick. It is sometimes necessary, however, to use one of these less desirable joints in moulds having liners of different thicknesses and where tongues and grooves are required.

To guard against the moulder's incorrectly placing liners in the mould box it is well to put a short pin in one side liner and one end liner, notching the mould box to correspond. These liners will not fit except in the proper place and will avoid troubles arising from inverted liners.

To insure easy removal of the moulded brick from the mould box a splay of approximately $^1/_8$ inch in 6 inches from the bottom

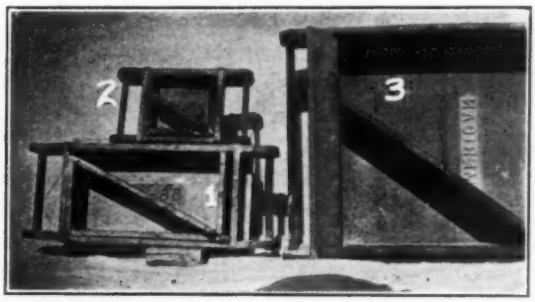

FIG. 10.—Mould 1 illustrates the method of butting the end of each liner against the face of the one preceding it. In mould 2 we see the miter joint, and in mould 3 the interlocking idea used in connection with the "butt end" liner.

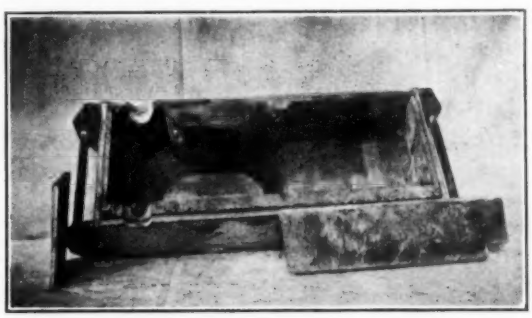

FIG. 11.—Illustrating the "splay" used in fitting liners to the mould box. The liner standing in front of the mould shows the splay at the end. The edge of the liners standing against the end of the mould shows the splay of the face, the top in this case being about an eighth of an inch thicker than the bottom.

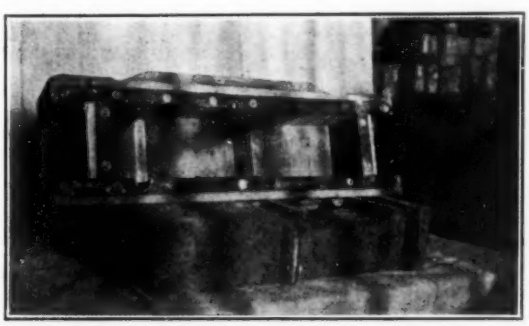

FIG. 12.—A wooden-screw mould and its product. Note the tongues and grooves and other irregularities of the brick. The brick is turned end for end but otherwise lies just as it would when dumped from the mould.

to the top of the box on both sides and both ends is allowed when the box is made, and the backs of the liners are machined to fit this, the working face of the liners being perpendicular to the bottom of the mould or having any angle with the bottom that is required in the brick (Fig. 11).

It is often possible and profitable to construct moulds of this type to make two bricks at a time, where the shape of the brick readily lends itself to such treatment. Two complete moulds are made with bottom, sides and one web common to both. Good results cannot be obtained if the separating web serves also as a liner, for it is held firmly between the brick after they are dumped on the pallet and there is danger of damaging the brick when it is removed. Two moulds together are filled almost as rapidly as one, rammed, hammered and struck off just as rapidly, so that more brick can be turned out by the same moulder in a day. Wherever the size and shape of the brick and pallets available permit such treatment it is recommended. Drying capacity may be doubled in this manner where it has been the practice to use a pallet to each shape.

Generally speaking there is no limit to the length of life of a well made all steel mould box, but wear on the top edge of the mould liners incident to slicking off each brick is considerable. The "slick" side of a brick produced in a worn mould exhibits a depression midway between the ends of the brick instead of the proper true flat surface. With some materials containing a limited amount of moisture such a brick will crack when turned onto the pallet, as the center will sag to conform to the flat surface of the pallet. Other materials containing more moisture will permit the sagging without forming a noticeable crack, but under fire the crack develops and the brick becomes a cull. Liners should not be allowed to remain in service until they produce such brick, but they do not need to go to the scrap pile.

In the hands of a competent mould maker the life of a liner may be extended to several times the length of the first wear. The liner is heated in a forge, laid on a flat steel plate with the working face down and stretched by means of a "fuller" which is applied parallel to and about $^1/_2$ inch from the worn edge. Two or three heatings may be required to obtain the proper amount of stretch.

The liner is then placed in a shaper and 2 or 3 light cuts made to true up the edge, and reduce the depth to the proper dimension. Generally there is a slight stretch lengthwise which may be ground down on an emery wheel. The liners are replaced in the mould box and will give as good wear as when newly made. The number of times a liner may be stretched in this manner depends on its width and the skill of the mould maker. Blocks and other irregularities riveted to the working surface of the liner should be removed when the stretching is done. Invariably these attachments will fit back into place with little or no trouble.

Wooden Knock-Down or Screw Moulds

Knock-down or screw moulds are made of wood lined with sheet iron, on the ends, sides, and edges to resist the wear, and joined at the corners by tongue and groove methods. The bottom is furnished with a shoulder having the same shape and dimensions as the inside of the mould, and is secured by clamping the sides down hard against the shoulder. Dowel pins are often used to insure correct fitting of the sides, ends and bottom together and contribute to the general rigidity of the mould (Fig 12).

Well-seasoned maple is probably the best wood to use in screw mould construction. It is less liable to split and warp, will take and hold screws and makes a good wearing job. Poplar may be used but is not so satisfactory. Soft woods and woods with a decided grain should never be used. The thickness of the wood selected should not be less than $1^1/_2$ inches and longer mould life is obtained when $1^3/_4$ and 2 inch stuff is employed.

Screw moulds (Fig. 13) have been used almost entirely in making large odd-shaped brick, in cases where it is difficult to design a satisfactory steel slip liner mould or when only a few pieces of a certain brick are required. In such cases the life of the mould will be in excess of the amount of work required of it. When put to considerable use, first cost is very often a small item compared to the repairs necessary to keep the mould in service. One of the first difficulties experienced with wooden moulds arises from swelling and warping which make it difficult, and eventually impossible, for the moulder to reassemble the mould properly.

Several poor brick are made during this time and as soon as the mould is checked as faulty it must go to the shop for repairs. While it remains out of service no brick are made. The side of a deep mould will split under the hammering of the moulder thus necessitating further repairs. When once the side is split, the mould becomes a cripple and will need constant attention, and brick made in it will not always stand rigid inspection. Even with a perfect screw mould, there is also the possibility that the moulder will fail to properly tighten it when putting it together. Poor brick are the result. The class of men employed as moulders should be furnished with tools as nearly "fool-proof" as possible. A wooden mould is far from being such a tool. It does not

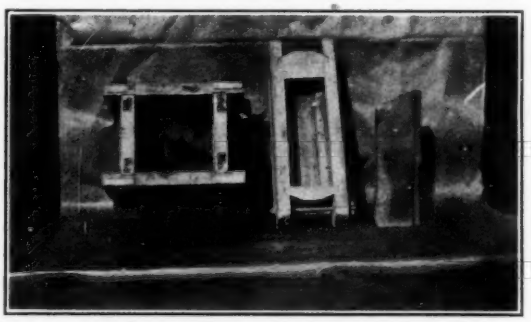

FIG. 13.—Two small screw moulds, one for a tap-hole and the other for a tuyere brick which stands beside it.

readily fall back into place after having been once taken apart for dumping a brick. As a result, the possibility of poor brick is very pronounced and only men who are capable of taking an intelligent interest in their work can handle a wooden mould profitably for themselves or their employers.

On account of the limited uses to which chrome brick are put, press-made standard 9 inch sizes fill nearly all requirements and as a consequence almost no hand-moulded chrome are made. However, some tap holes and nozzles are used and either slip liner or wooden screw moulds are used in their manufacture.

Magnesite standard 9 inch sizes and a great variety of special

shapes are now made by the press method and the matter of hand moulding in this branch of the industry will receive less and less attention as time goes on, due to the diminishing number of special brick which require hand moulding.

Until recently silica brick have always been exclusively hand moulded. At present time a machine for the mechanical moulding of standard 9 inch sizes is being developed which may in time be adapted to manufacturing the larger standard sizes. It seems probable that mechanical moulding of these standard sizes should within a short time altogether replace hand moulding. This will be a long step in the right direction for while the purchase and use of refractory products will always be subject to caprice and prejudice born of false theories and poorly taken or incomplete information, their manufacture should not be affected by the human element to such an extent. Mechanical moulding will eliminate a great deal of the personal equation.

A large proportion of the breakage encountered in the manufacture of hand moulded refractory products may be traced to the variation in density in different parts of the brick when it comes from the mould which results in uneven expansion or shrinkage while under fire thus producing cracked and deformed brick. Beyond doubt this is due to the uncertain treatment which the brick making mixture receives at the hands of the moulder. This condition is almost entirely eliminated in press made brick where the personal equation is not operative.

Special shapes of silica will probably always be hand moulded on account of the diversity of sizes, shapes and uses. Mechanical moulding of this class of product would demand similar machinery to that used in manufacturing electrical porcelain and would require a radical departure from the mud mixtures now used. The investment necessary for moulds in such a case would be out of the question as changing practices among the users of this type of product will not permit a standardized brick. This is particularly true of coke oven brick. It is, however, within the range of possibility that large shapes of all kinds will soon be made on the same principle that is now being developed for the manufacture of the standard sizes, although the chances of automatic dumping devices in this connection seem to be very remote.

It has been said that in another twenty years coke ovens will be constructed out of standard 9 inch or similar sizes and that special shapes now used will be discarded entirely. In that case hand moulding of silica brick may be done away with altogether. This will mean radical departure from present day practices but there is reason to believe that such changes will come and they are bound to be profitable both for the manufacturer and the consumer.

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GLASS CONTAINERS[1]

A. W. Bitting

ABSTRACT

For centuries glass bottles have been recognized as superior containers. At present over 4000 different sizes and shapes are being made and the industry is in a state of rapid extension. Glass containers possess the advantage of being sanitary and permitting the contents to be seen. Recently the laboratory of the Glass Container Association has tested 180 lots of beverage bottles. Some of the better types, or those approaching the champagne style, were found to withstand an end crushing pressure of from 8000 to 12000 pounds, a transverse pressure of from 800 to 1800 pounds, a hydrostatic pressure of from 400 to 1600 pounds, and an impact of a fifty-pound hammer falling from 2 to 6 feet. Similar tests are in progress on other types of containers and on the closures employed. Troubles due to alkalinity are of rare occurrence.

Historical

Nearly thirty-five hundred years ago a Theban ruler, Amenophis, erected the great granite monument, the Colossus of Thebes, and inscribed his name thereon. The granite typified endurance and resistance to all time. But the centuries have wrought destruction and the elements have worn away the surface so that the name is gone except as record of it remains in history. Within this monument was a delicate scent bottle made of yellow glass and upon it is inscribed in blue characters the name of this same king. This light fragile bottle, protected by the heavy granite walls of the tomb, connects the present glass industry with that period. It is the earliest glass bottle known to be marked in such a manner that it may be identified with some person, place, or date. Glass ornaments for personal adornment are known to have existed for many centuries prior to that time; some of the drawings in earlier tombs show bottles being used for wine, but this marks the beginning of known specimens.

It is not at all strange that the early pieces were for scent bottles, perfumes, ointments, and other toilet preparations as they were

[1] Received September 29, 1921.

necessarily small and costly. They would appeal to the rulers and to the wealthy few as next to jewels and insignia. They evidently served well as precedent for at no time since have they been supplanted for the purpose; the highest skill on the part of workmen, blowers, cutters, decorators, and jewelers has been and is still expended in fashioning them. Their appeal is not only to those of means, but highly artistic forms are made to meet the wishes of all who feel the need of cosmetics to accentuate their personal charms.

The wine bottle receives a particularly early mention and its advantages as a container are made a matter of record. It seems to have been among the first of the bottles of fairly large size, and the first to have been made in quantity after the art of blowing was introduced. The Phenicians added the seal or date to this bottle. The advantage of long aging of wine seems to have been fully appreciated and in the period of the Roman empire Horace observes at a feast that "They immediately bring in glass bottles carefully sealed; on the neck of each is a label, marked thus: 'Opinion Falerian one hundred years old.'" Pliny states that some of this vintage was held for two hundred years. The bottle continues to maintain its place as preëminently the container of choice where wine is made.

Galen, the most celebrated of the Greek physicians gave an impetus to the use of the bottle for holding medicines or pharmaceuticals, "because from it cometh no smell or bad odors." In the excavation of the ruins of Pompeii a surprisingly large number of bottles were found showing how the "ancient housekeepers, kept their wine, oil, vinegar, honey, preserved apples, dried figs, prunes, beans, and barley." Some bottles of similar form are still in common use. The progress since that time has been in the production of a better and more brilliant quality of "metal" and the uniformity in size and finish which comes from the application of modern mechanical methods.

The glass industry was the first manufacturing enterprise to be established in this country. A furnace was built near Jamestown, Va., in 1608, where a few bottles were made, some of which were sent to England the following year. Ever since then glass factories have followed the march of the settler and met his re-

quirements. The one outstanding feature of the development of the industry in America has been the application of mechanical processes to reduce hand labor and to secure greater brilliancy of "metal" and uniformity and accuracy in containers. The glass industry has always been considered one which is unusually hazardous, the life expectancy of its workers being rather short. It has been a seasonal occupation with much time lost in idleness. The substitution of coal for power, and the adoption of inanimate machines which know neither hot nor cold weather, nor hours nor days, to turn out containers from one-fourth of an ounce to twelve gallons at a speed and low cost which permits their use in hundreds of ways, was never contemplated by the most imaginative even a hundred years ago. The most rapid transition in the entire history of the industry is being enacted at this time. It will only be a little while until the machine will supercede all hand work as completely as the power loom has for woolen cloth. There will always be a place for the human glass blower who has the artistic taste and skill to execute the exceptional article for limited use and quantity, but not in competition with those forms or patterns which are turned out by the thousands.

Types of Glass Containers

The present glass container is a good deal like Topsy; it "just growed." It is supposed to represent the whims and desires of hundreds of users, but more likely represents the persuasive efforts of many salesmen from the glass factories. These salesmen have taught their customers that there is vast wealth to be obtained by distinctive designs. Possibly there is, for it is said that we have more than four thousand shapes and sizes and special designs, not counting names or trade marks. The result is containers of all kinds for all purposes, many good ones, some indifferent, and some poor. From this heterogeneous mass there will gradually evolve standard types to care for the business in different lines. There will come a recognition that the glass container has two quite distinct functions, one to carry and protect its contents while at the same time making them visible to the user; the other, to serve as an ornamental package. The

ornamental qualities in glass are so naturally inherent that attempts to combine the latter functions with the former have resulted in hundreds of monstrosities which are weak as carriers and devoid of artistic merit. There is a place for the container *per se* and another for art glass. Fortunately too, strong carrying bottles can be made with attractive lines, good proportions, and clean "metal," befitting both the contents and the package. Manufacturers and packers will learn in time that tall bottles and jars with narrow bases can not be handled with the same ease by machinery as the more sturdy types. They will learn too, that they can not handle a dozen to twenty sizes and shapes with the same economy as two or three and that the differences in cost are not due to the glass used but to the stock carried, greater number of machines needed, increased labor in handling, multiplicity of labels, cartons, and shipping cases, and the storage space required. Through the costly school of experience they will eventually learn that certain shapes lend themselves to pasteurization and processing better than others, and that the laws of physics relating to expansion and contraction can not be set aside just to have a panel bottle. Boards of Health through the enforcement of ordinances requiring the cleaning and sterilization of re-usable bottles, as for soft drinks, will gradually drive home recognition of the fact that some styles are much more difficult to clean than others. The present studies upon shipping will cause some manufacturers to take notice of the fact that those forms which present a large surface to resist impact will carry much better than those whose form presents a small area to receive the blow. In other words, the manufacturer of glass and the user of glass are arriving at the point where they must work together on their problems, if quantity and economical production are the ends to be sought by both. If this sounds like an array of the faults or weaknesses of the glass container, nothing could be farther from the intent. It is a pointing out of a few of the factors at work which will bring about greater changes and more rapid extension of the use of glass in one or two decades than have ever taken place in a century.

American made glass containers may be classified as follows:

Beverage bottles: Pressure ware, for carbonated sodas, ginger

ale, etc.; non-pressure ware, for mineral waters, grape and other fruit juices, etc.; milk; and liquor containers.

Proprietary and prescription bottles: Round, oval, square and panel bottles for patent and proprietary medicines, prescriptions, flavoring extracts, etc.; perfume and toilet bottles.

Food containers: Wide mouth, for preserves, jams, jellies, marmalades, etc.; narrow mouth, for sauces, ketchups, salad dressings, syrups, vinegars, etc.

General purpose containers: Wide mouth, for dry drugs, chemicals, and heavy materials; narrow mouth, for drugs and chemicals, oils, varnishes, polishes.

Large containers: One to twelve gallon bottles and carboys, for water bottles and chemicals.

Special containers: For battery jars, display jars, etc.

Extension of the Use of Glass Containers

At the present time there is a rapid extension of the use of the bottle for soft drinks and the materials used in their manufacture. There are two reasons, one being the eighteenth amendment to the constitution, which is probably not the greater, the other that the ordinary soda fountain is not sanitary. The local water supply in hundreds of towns and smaller cities is not protected from pollution, and discriminating people prefer to obtain their refreshments in a container which has been handled and filled in a place where sterilization is a part, and a fundamental part of the business. Uniformity in quality through exact compounding, and safety of the sterilized product do appeal, and even the unthinking gradually acquire the habit of "safety first." The soft drink industry has had a sudden and unexpected growth which has been to its disadvantage, but as it becomes older and acquires a normal development, it promises to expand to larger proportions than the bar trade which it has supplanted. Its patrons are the whole family instead of only the head, and if properly developed with the use of wholesome materials, it must necessarily follow that there will be continued growth of the industry with a large extension of the use of glass.

The milk bottle was born of progress and was christened only a few years ago. In two decades it has almost supplanted the tin can and dipper in every city and village in the country. The greatest stride in making milk safe and wholesome has been based upon this cleanable, sterilizable container, and the limit of expansion has not been reached.

Liquor containers or containers for spirituous and fermented liquors have suffered a marked decline in number and no comment is necessary.

The other field of increasing interest is that of the food container. When one enters the grocery store in the largest city or smallest village, the most prominent feature on the shelves is row upon row of canned foods. The impression is gained that no others are packed, but such is not the case. We have the means of knowing how many preserve jars are made and the amount of ware produced for jams, canned fruits, etc. We also have a fair notion of the re-use of jars in the home. The total quantity packed in glass is far in excess of that previously estimated even by food experts. The art of food preparation has not all passed from the kitchen to the factory and if we may judge from the number of capping devices sold, the art, or at least the labor of home brew, is returning to the same place. The amount of new foods in glass is increasing by leaps and bounds. Peanut butter was an oddity ten years ago, but is now almost a staple. Mayonnaise dressing and salad dressings of a similar type which were made only to fill in a complete line of groceries, and even sold in split cases, now require millions of bottles and will soon rival ketchup in the quantity required. Vinegar and pickles are being taken out of the class of barrel or bulk delivery in favor of the individual, sanitary package. The former alone will require several million more bottles this year than ever before. Syrup manufacturers have learned the lesson from honey distributors, that people do, in a sense, eat with their eyes and like to see what they buy. Experiments conducted in the laboratories of the Glass Container Association have demonstrated that there is a decided gain in holding nut meats in vacuum jars, that in these containers there is less change due to drying, that they may thus be kept during the summer without refrigeration, and that

the rancidity of the oils and the development of a bitter taste may be avoided. This suggests other experiments and possibly new uses for glass.

Experimental

While the foregoing indicates very briefly the lines in which expansion is developing most rapidly, there is another phase of industrial activity set in motion to keep pace with the expanding uses, and that is the study of the container itself. The bottle or jar is not complete without a proper closure, and the history of the numerous efforts made in this direction is told in the long list of patents granted by the Patent Office. A great deal of inventive genius has been expended along this line, but most of it has come to naught. The best bottle or jar, used with the best designed closure, will not work unless the two fit, and as a rule the makers of each have not known the limitations of the other. In order to avoid such difficulties in the future, the glass manufacturers and the closure manufacturers are working together, fixing the standard sizes of openings, the height, thickness, and pitch of the thread for all screw caps, the shape of the lip for crowns, and the finish for various other closures. This means standard molds for the one and dies for the other, and most important of all, an insured tight seal to the user. This is but one step which eliminates hundreds of off-size designs and which gives a flexibility in purchasing not heretofore enjoyed. It will take time to complete this work but it is well under way.

The bottle itself is being subjected to study along new lines. During this summer, the association laboratory tested one hundred and eighty lots of beverage bottles as a preliminary step in determining their strength and suitability to meet certain requirements. There were no precedents to serve as guides, and therefore no handicaps in that direction. Direct pressure was applied both vertically and transversely to the exterior of the bottle. The pressure was applied by means of a screw and scales for some of the lighter bottles, but the majority required a regular testing machine. A piece of sheet copper was placed between the bottle and the metal of the testing machine. Hard maple was first tried but the mouth of the bottle was frequently forced into the

wood to the distance of one fourth inch or more. Crown seals placed over the mouth assisted but were not sufficient as they were sometimes imbedded in the wood. The transverse pressure was obtained by placing the bottle between two pieces of hard wood, two and one-half inches wide and at least one inch above the bottom. These tests show that beverage bottles have a high resistance to direct pressure. Many bottles withstood vertical pressure between 8000 and 12000 pounds and transverse pressure between 800 and 1800 pounds. Whole groups averaged better than 5000 pounds vertical pressure and 1000 pounds transverse pressure. As the glass in a transverse section of the smallest part of the neck of a bottle is often much less than one-half a square inch, these figures give a compression strength to bottle glass somewhat higher than has usually been thought to be possible. A hydrostatic pressure was obtaind by filling the bottle with water and then using a pump and recording the breaking point. Some of the heavier bottles recorded 1600 pounds before breaking and several groups showed an average in excess of 400 pounds per square inch. This likewise is greatly in excess of the pressure of any of the highly carbonated beverages. An impact test was applied by fastening a hardwood butcher's block to a steel frame and resting the bottom of the bottle against the block. A hammer was provided with a handle five feet in length and suspended as a pendulum. A hardwood block was interposed between the bottle and the hammer. These bottles withstood drops of a fifty-pound hammer from a little less than two feet to more than six feet, or, corresponding to from 85 to 300 foot pounds. This impact test probably has more value than the direct pressure tests, as it is from blows of one character or another that most failures occur in glass in ordinary usage. A further test was made of the power to withstand sudden changes in temperature. The bottles were immersed in cold water and then transferred to a bath one hundred degrees higher. This is as wide a range as would be found in commercial practice in washing or sterilizing bottles, and was practically without breakage. On changing in the reverse direction, breakage did occur, but there is little, if any, reason for a sudden drop of such magnitude in actual use.

The bottles were grouped according to diameter, capacity, weight, ratio of weight to capacity, and shape, for the purpose of comparing the various tests. It is not possible to detail the results here but any bottle with a long sloping shoulder of the champagne type, having an even distribution of metal and being well annealed, is a strong type. These tests do not tell the whole story but they do serve as a starting point for future work.

A similar line of work was carried out with prescription bottles of various sizes from one-half to sixteen ounces, of the round, oval, square, and panel types. These bottles are obviously not as heavy nor as strong as the beverage bottle, as they are generally handled carefully and rarely have a re-use. The round type is distinctly the stronger, then follows in order the oval, square, and panel. These tests have a more important bearing in connection with bottles for patent and proprietary preparations which must stand shipping hazards after being filled, than upon the prescription ware which is passed from the druggist to the purchaser. The uneven distribution of glass due to square shoulders, sharp corners, flutes and panels, and irregularities in shape which permit excessive pressure on small areas in packing, help to make the difference between the non-fragile and the ware which needs the label "handle with care."

Experiments have also been carried on with corks or seals to determine their resistance to leakage, not merely liquid leakage but passage of gas as in the case of carbonated beverages or air in the case of still products. This naturally included jars and bottles subject to pasteurizing and sterilizing processes. One can now purchase closures which vary from those that will leak like a sieve, to those which will resist a pressure of more than 200 pounds.

The matter of the soluble alkalinity of glass has been receiving more attention recently than at any time in the past. Troubles from this source are of such rare occurrence that they receive undue notice because of that fact. It is probable that less than one-twentieth of one per cent of the articles packed are affected by free soluble alkali. American bottles are better in this respect than foreign ones, if the figures available admit of making a comparison.

Science came to the rescue of optical glass during the war. The results were marvelous. The manufacturers of common glass have taken notice and are applying in a small way the same line of attack to their problems, and as they produce results we may expect an extension of the work.

OBSERVATIONS ON THE FACTORY CONTROL OF FISH-SCALING[1]

By John S. Grainer

ABSTRACT

An analysis of fish-scaling, its causes and prevention, based upon observations and experience of practical work. Three principal causes of fish-scaling are: (1) Improper firing, either underfiring or overfiring, especially the latter since its effects are usually not evident until the ware is finished and marketed; (2) The use of a clay which does not give a free running uniform coat without the use of excessive amounts of flotation agents. Clays which, when stirred up with water give a persistent suspension are recommended. (3) Improper type of furnace for the firing operation. The author prefers the open type furnace for the firing of enameled ware.

To the uninitiated, the cause and control of fish-scaling seems of very easy solution, but to those familiar with enameling operations it is a serious question and a matter of vital importance; for unfortunate is the enameler whose ware is suffering from an aggravated case of this troublesome pest. So many causes have been attributed to it, and it occurs under so many different conditions and stages, that one is at a loss to know from what direction to attack it. Among the causes which have been advanced are the following: improper smelting, character of clay, improper milling, character of iron, lack of regulation of the acid bath, type of furnace, underfiring, relative coefficient of expansion of enamel and steel and such a host of other causes that upon investigation we rarely find two enamelers holding the same opinion.

Of the above causes, underfiring, character of clay and type of furnace, are the ones selected by the writer for a brief discussion. The remaining causes appear to be of secondary consideration. Still at times the writer is tempted to believe that the character of the iron may be an important factor. Nor can we ignore the fact that the established law of expansion and contraction holds an important place, being held by many as the

[1] Received August 18, 1921.

primary cause, not so much in its action alone but through other contributory causes that tend to rupture the enamel during the expansion and contraction of the ware. The glass maker has been successful in controlling this situation by the manipulation of materials and conditions until it is possible to expose certain glasses to extremes of heat and cold without fear of rupture. The enameler of cast iron has also been highly successful in this respect. But the enameler of sheet steel has not been as fortunate and his inability to definitely explain the phenomena has made him a target for criticism.

Taking up the first subject for discussion, that of underfiring, the writer believes that one of the principal causes of fish-scaling of finished ware is not so much underfiring as overfiring. An experienced burner can detect a piece of underfired ware quicker and with more certainty than he can tell a piece that has been overfired. For the writer knows of no rule to determine whether a piece, that to all appearances has been properly burned, will fish-scale or not until the trouble actually manifests itself.

This brings forth the question as to what change or action takes place from overfiring. If we should apply a uniform coat of enamel frit or glass that had been finely milled without clay to a piece of sheet steel and burn it, we would find upon withdrawing it from the furnace that its high luster and pleasing appearance apparently make an ideal coating; but after it is cooled we are not surprised to see the coating shivering off of the piece until the metal is bared, due to the absence of clay. On a second piece we repeat the operation but add clay in the mill and after burning and cooling the shivering has ceased or diminished according to the percentage of clay added. We will proceed to refire the piece containing the clay without recoating it and subject it to the intense heat generally used in ground coat burning and we find that if overfiring has taken place, one of three conditions are present—either the ground coat is sintered; the iron scale has forced its way through the enamel; or the ground is burned to a greenish brown color. Here the writer claims the damage is done, as the prolonged intense firing has destroyed or changed, either entirely or in part, that property of the clay that tends to regulate the gravity of the enamel until we find

after burning nothing is left on the ware but the ground frit or glass minus the clay, or essentially the same conditions we had on the piece that shivered off.

Fish-scaling from underfiring generally takes place upon the cooling of the ware or within a few hours after burning and it is the contention of the writer, based on factory observation, that the scaling from overfiring while not so conspicuous or prominent as the former is nevertheless just as persistent and does not occur until a few days up to two or three months after the ware is finished. As the ware is generally white coated the same day or the day following, it can be readily understood how very easily it is possible to overcoat a condition of fish-scaling that will not manifest itself until it is on the market. To white coat a piece of underfired ware that looks suspicious is simply inviting disaster from which the enameler cannot escape; but until some definite rule or means are discovered to also avoid the overfired piece we can only hope to follow the beaten path of taking chances.

There is no question but that pieces of underfired ware will at times pass unnoticed through the various operations and find their way to the market, but the amount of fish-scaling one sees in the display windows of various cities, both on stove, hollow ware and refrigerator works, is *prima facie* evidence that it is not all due to underfiring for the amount is too great to pass unnoticed if underfired. Therefore, we can reasonably suspect that it is due to the fact that the ware had been overfired and that the retarded scaling resulting therefrom did not manifest itself until after the ware was on the market.

In considering the second cause of fish-scaling, namely that of clay, the writer believes that herein lies the most important factor entering the enameling of sheet steel. The pride of every enameler is a reliable ground coat formula which he regards as his most treasured possession, and rightly so, for herein lies the secret of his success. We can expect that his ground coat, if properly used, will not fish-scale. The term "properly used" in this case simply means that the clay used is of the right character to make possible proper slushing and burning of the ware.

In discussing the effect of overfiring, we alluded to a particular

point at which the efficiency of the clay was destroyed; remembering this point, we must select a clay that will still retain its efficiency at the higher temperatures. Still another and more important requisite, is the selection of a clay that will hold the frit in suspension without the excessive use of flotation agents. An enamel ground coat applied too thinly, and fired too hard will fish-scale and enamel applied too heavily and underfired will do the same. On irregular shaped ware that has been dipped or shaken out, or on pieces on which the ground is required to flow from different angles, it becomes almost impossible to apply a uniform coating. Consequently upon firing we have two extremes to overcome at the same time. If we overfire the one part we underfire the other—hence, the importance of a free running clay that will insure a uniform coat on all parts of the piece. The non-uniform condition of the ground coat is very often the cause of fish-scaling on certain areas of the ware.

In selecting a clay the writer has used a very simple but satisfactory method of testing the ability of the clay to remain in suspension. Six one-quart Mason jars were procured, also samples of six of the leading well known American and foreign clays, regardless of their chemical analysis or prestige. Into each jar one pound of clay was placed and the jar filled with water. This was allowed to stand a few days until the clays were thoroughly saturated, after which they were all stirred by hand as quickly as possible and were then allowed to stand one week, after which the following data were noted. Four of the clays settled to the bottom of the jars in six hours, some more compactly than others. One, a washed clay, while not settling very fast, gave evidence of being held in suspension by the addition of some chemical agent. The remaining clay settled about one-half inch and remained so until the water was entirely evaporated from the surface, a matter of thirty days' time. This one showed no evidence of being chemically treated and was selected by the writer for further experiments for the reason that, if the other clays could not hold themselves in suspension, they certainly could not hold the frit. A batch of frit was then milled with ten per cent of this clay and the results were good. Suffice it to state that this clay was adopted.

The irregular shape and size of a refrigerator lining requires the entire immersion of the piece into a tank of ground coat of about one hundred and seventy-five gallon capacity. When the plant at which the writer is employed first started operation four years ago, it was very difficult to get a clay that would deposit the frit uniformly over the piece, consequently much fish-scaling appeared on the parts where the enamel was too thin or too heavy. With the changing of the clay and firing conditions corrected, this trouble has entirely disappeared. During the war the plant was obliged to shut down for a period of five weeks, the supply of fuel oil having been exhausted, and the writer was very much gratified upon returning to find the ground coat was still in a good state of suspension with very little precipitation at the bottom of the tank. Hence, we find from this that the flotation element of a clay holds a very important place in the occurrence of fish-scaling, as it not only makes it possible to apply a more uniform coat, but in a furnace of even heat distribution the firing is more uniform and more easily controlled.

The third and last cause of fish-scaling selected for discussion relates both to firing and the type of furnace used, and while it appears the last for discussion, it is by no means the least, for the results of our attention or our inattention to the details leading up to the firing operation will be indelibly engraven on the surface of the piece after firing. The old adage that "a poor workman will kick on the tools" is at times only too true. But after viewing some of the furnaces in different plants the writer is convinced that the workman often is justified in his "kicks." No matter how carefully details have been accounted for up to the firing operation, the labor will be in vain unless the means for proper firing conditions have been considered. The industry is awakening to this fact and as a consequence many new types of furnaces are being introduced, and while the intermittent firing open type furnace is not of recent origin it is now rapidly displacing the muffle type in many plants for the following reasons: It has a more uniform distribution of heat which insures the uniform firing of all pieces of ware, thus reducing the risk of over- or underfiring; as the firing is discontinued while the ware is at high heat, economy in fuel is obtained. Its solid construction

of standard fire brick minus special forms adds to its life thereby reducing the upkeep and making possible the firing of the ware without deformation of the muffle. Added to this advantage, its complete absence of gas makes it an ideal furnace. What relationship exists between fuel gas and fish-scaling, if such does exist, is not known. That its effects are injurious to the enamel cannot be doubted by the appearance of the disagreeable bluish color imparted to the ground when fired in a furnace containing gas. That there is a difference in ware burned in a muffle type of furnace and in the open type is beyond doubt. The fact that the muffle type is very seldom free from gas due to leaky joints or defective flues, while the open type is entirely free from gas gives strength to the opinion of many that the action of gas is a contributing cause of scaling.

Another important condition often overlooked in firing the ware is that the ground coat is applied too thinly and fired too hard. The fault does not lie so much in the length of time consumed but more in the severe high temperatures carried, no provisions being allowed the ground coat for the subsequent firing of the white. This is especially true of samples of hollow ware examined, for upon breaking through the white, one will find scarcely any traces of the ground. The result is that what anchorage the white depended upon from the ground has been destroyed by overfiring, a condition which later may cause fish-scaling or which will not permit the abuse to which the ware will be normally subjected.

The writer has long held the opinion that all sheet steel enamels could be so formulated as to lower their firing temperatures so that after firing, the ground remained intact. While this may not be possible on hollow ware, owing to the hard acid-resisting whites used, this rule can be applied to stove, refrigerator and kindred lines and would result in more shapely and durable ware.

In conclusion, the writer would state that the plant in which he is at present employed is in the fourth year of its production. During the first two years in which the muffle type of furnace was used the firm was about convinced that it had an unwelcome monopoly on fish-scaling and years of past experience availed naught in correcting the trouble. Every source from which it

might originate was thoroughly investigated and from the conclusive evidence of the results obtained the causes were traced to the three conditions under discussion, namely, overfiring, clay, and furnace construction. An open type furnace was installed, firing conditions corrected and the ground coat so formulated as to mature at lower temperatures. A clay was selected that would hold the frit well in suspension without the excessive addition of flotation agents, while a more uniform application of the ground coat was produced. In the last two years, since the change was made, with the exception of an occasional piece that could be readily traced to underfiring, all pieces have been free from fish-scaling.

Not on any one of the conditions alone depends success but on the three combined. A successful furnace will not produce satisfactory results unless the dipping or slushing conditions have been properly controlled and this in turn cannot be made possible without the use of the proper clay. Yet it is very evident that if the three conditions are carefully regulated the general result will promote success.

GRAND HAVEN, MICH.

PHYSICAL DEFECTS IN TANK BLOCKS[1]

By Geo. A. Loomis

ABSTRACT

An investigation of some of the leading makes of tank blocks of flux grade tends to show that these blocks as a class, are not as free of physical defects, such as fissures and lamination, as could be desired. Photographs are shown of representative sections of the blocks examined.

Physical defects in tank blocks, such as fissures and lamination, especially in the so-called flux grade, are generally conceded to be detrimental to the life of these blocks in service, and hence, to the life of the tank, since the glass more readily penetrates and attacks the blocks when such imperfections are present.

An investigation, made by the writer about two years ago, in the interests of the Corning Glass Works, Corning, N. Y., and which included some of the leading makes of flux blocks, indicated that such blocks, as a rule, were not as free of physical defects as could be desired. The blocks included in the investigation were made during the war period and were said, by some of the manufacturers, to be below their usual standard in freedom from defects. Recently-made blocks of some of the same makes have, however, shown but little, if any, improvement in this respect. The data obtained in the investigation mentioned is, therefore presented herewith to point out the need of improvement.

The investigation was made as follows:

Three blocks were selected at random from carload shipments of each of three makes. One block was likewise taken from a small shipment of another make. These blocks were carefully cut up into sections about three inches thick by cutting all around the block with a broad chisel until the section became detached from the balance of the block. In all but one or two instances, these sections were removed intact. Whenever a loose "sliver" remained attached to the section, it was carefully removed to avoid

[1] Received Nov. 21, 1921.

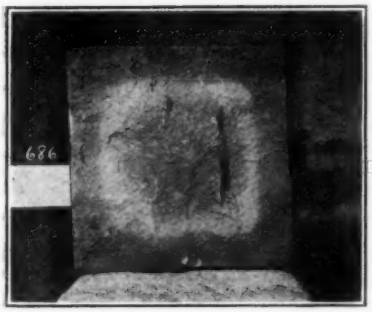

FIG. 1.—Representative section of Block No. 1, Make No. 1.

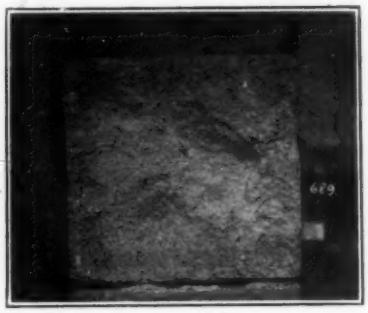

FIG. 2.—Representative section of Block No. 2, Make No. 1.

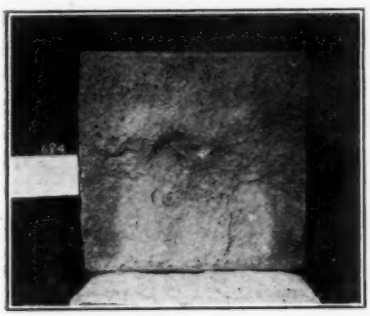

FIG. 3.—Representative section of Block No. 3, Make No. 1.

FIG. 4.—Representative section of Block No. 1, Make No. 2.

FIG. 5.—Representative section of Block No. 2, Make No. 2.

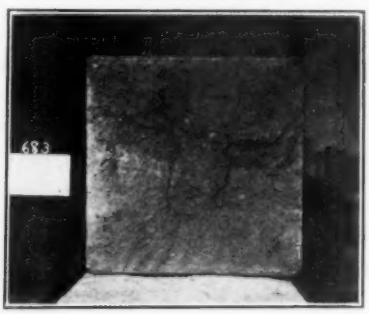

FIG. 6.—Representative section of Block No. 3, Make No. 2.

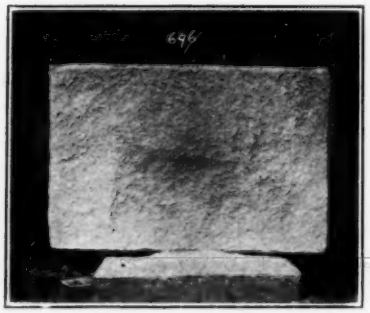

FIG. 7.—Representative section of Block No. 1, Make No. 3.

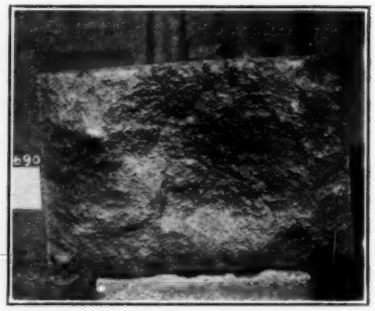

FIG. 8.—Representative section of Block No. 2, Make No. 3.

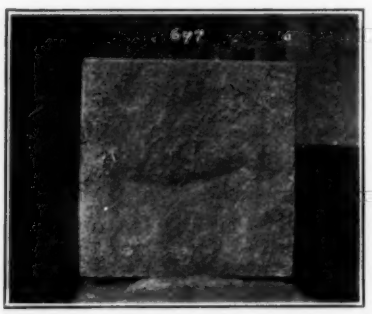

FIG. 9.—Representative section of Block No. 3, Make No. 3.

FIG. 10.—Representative section of block of Make No. 4.

mistaking it for an imperfection. Each section was then carefully examined and note taken of the size and number of fissures and other defects present. A photograph was taken of a representative section of each block.

The observations made in the examination of the various blocks were as follows:

Block No. 1, Make No. 1.

1st section: One fissure 3″ by $^1/_{32}$″; three or four fissures $^1/_2$″ by $^1/_{16}$″; quite a number of small pin holes.

2nd section: One hair-line crack 2″ long; six or eight small holes about $^1/_{16}$″ in diameter; quite a few pin holes and small cracks.

3rd section: Two fissures, 1/16" by 3/4"; five or six holes 3/32" in diameter; one hair-line crack 1" long; many small pin holes.

4th section: Four fissures, 1" to 1 1/2" long by 1/32"; two holes 1/8" in diameter; quite a number of small checks and pin holes.

5th section: Six fissures 3/4" to 1" long by 1/16" wide; a considerable number of pin holes.

6th section: One fissure, 3" by 1/8"; one hole, 1/4" by 3/4"; another, 1/8" by 1/2"; another, 1/4" in diameter; two or three fissures, 1" by 1/16"; quite a few pin holes.

It will be noted in the representative section, shown in Fig. 1, that this block also shows evidence of being improperly burned.

Blocks No. 2 and 3, Make No. 1.

The defects noted in the various sections of these two blocks were very similar to those noted in block No. 1. Representative sections of these blocks are shown in Figs. 2 and 3, respectively.

Block No. 1, Make No. 2.

1st section: One fissure 8" long by 1/32" wide; three 1 1/2" to 2" by 1/32"; two holes 1/8" to 3/16" in diameter; many small pin holes.

2nd section: One fissure 6" long, 1 1/2" of which was 3/32" wide, and the remainder 1/32"; two fissures 2" by 3/32"; two holes 1/8" in diameter; quite a number of small checks and pin holes.

3rd section: Five fissures 1" by 1/32"; two 2" by 1/32"; one hair-line fissure 3" long; one irregular hole 1/4" in diameter; quite a few pin holes.

4th section: One fissure 3" by 1/32"; one hair-line fissure 4" long, and another 2"; one fissure 1" by 1/8" to 3/32"; three or four 1/2" by 1/16"; a number of pin holes.

5th section: One fissure 6" by 1/16"; two 1 1/2" to 2" long by 1/32"; several small checks and pin holes.

6th section: Several hair-line fissures 2" to 3" long.

A section of this block is shown in Fig. 4.

Blocks No. 2 and 3, Make No. 2.

The size and number of defects in these blocks were much the same as those in No. 1 of this make. Figs. 5 and 6 show representative sections of these blocks.

Blocks No. 1, 2 and 3, Make No. 3.

Not a fissure or other defect could be discovered in any section of these blocks. All three blocks showed a very compact structure throughout. Sections of these blocks are shown in Figs. 7, 8 and 9. No. 2 block (Fig. 8) was red in color and shows dark in the photograph so that the actual lack of any defect is not very apparent.

Block of Make No. 4.

An average section of this block is shown in Fig. 10. Each section showed much lamination with many fissures, some of them being 3″ to 4″ long and $^1/_4$″ wide; also numerous small checks and pin holes.

It will be observed from the foregoing data that physical defects were present to an objectionable extent in all but one of the makes examined. As already stated, recently-made blocks of some of the same makes have been observed to be defective to practically the same extent, and inasmuch as some of these makes are considered among the best on the market, it would appear that there is in this respect, room for considerable improvement in flux blocks as a class.

The fact that all of the blocks of one of the makes examined showed a total absence of fissures, lamination and other defects would seem to indicate that the maker of these blocks has found a method of eliminating such imperfections. At any rate the specimens examined show that it is possible to produce tank blocks entirely free of these defects. It would, therefore, seem that the blocks of other makes could at least be materially improved in this respect.

It is not intended, in this paper, to suggest a method of eliminating these defects. It might be stated, however, that, judging from appearances, closer supervision of the molding by the present method would, in some cases, materially reduce the number of badly defective blocks.

WASHINGTON, D. C.

EFFECT OF WEATHER UPON THE STRENGTH OF REFRACTORY BRICK.[1]

By R. M. Howe, S. M. Phelps, and R. F. Ferguson[2]

ABSTRACT

Magnesia and silica brick should be protected from the action of the weather.

Open textured fireclay brick (usually having end cold crushing strengths of less than 1500 pounds per square inch) should be afforded protection from the action of the weather.

Finely ground, dense, hard-burned firebrick, especially those of medium or low refractoriness, may be exposed to the action of weather with a reasonable amount of safety. These are usually made from one clay which is shaped on a dry press or auger machine and have an end cold crushing strength approximating 5000 pounds per square inch.

Introduction

In many cases extreme care is exercised in the storage of refractory bricks to protect them from the action of the weather. At certain plants kilns of magnesia brick are not unloaded in rainy weather. In other instances bricks are given little or no protection from the action of rain or even snow. While good practice would favor careful storage, it should be remembered that clay bricks are used for paving and building and undergo very little deterioration due to the action of the weather.

Inasmuch as there were no definite data as to the effect of weather, the tests herein described were started December 15th, 1919, in order to secure definite information on the subject.

Materials Used

Fireclay, silica and magnesia brick were purchased in the open market for use in this test. The fireclay bricks of type "A" were made from semi-flint clay and were of first quality

[1] Received Nov. 24, 1921.

[2] Contribution from the Refractories Manufacturers Association Fellowship, Mellon Institute of Industrial Research, Pittsburgh, Pa.

refractoriness. The fireclay bricks of type "B" were made of about 80 per cent of flint clay and bats bonded with 20 per cent of plastic clay. The silica brick were typical open-hearth and by-product coke-oven brick. The magnesia brick were representative machine-made brick, such as are used in the metallurgy of iron, steel, and copper. The analyses are presented in Table I.

TABLE I

ANALYSES OF REFRACTORY BRICK EXPOSED TO WEATHER

Kind of refractory brick	Fireclay brick "A"	Fireclay brick "B"	Silica brick	Magnesia brick
Silica	50.98	55.02	96.58	7.80
Alumina	43.94	39.89	.74	2.42
Ferric Oxide	3.16	3.63	.50	3.62
Lime	.36	.86	1.88	3.86
Magnesia	.52	.26	.16	82.40
Alkalies	1.32	.79	.21	trace
Total	100.28	100.45	100.07	100.10

Method of Exposure.[3]

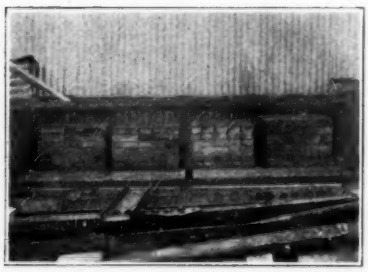

FIG. 1.—Method of exposing refractory brick.

The bricks were piled on the ground about 10 high in a wire pen which was open at the top and protected on only one side (see Fig. 1). Samples were reserved for testing and the rest were stored for 3, 6, 9 and 12 month periods. Care was exercised at the expiration of these intervals to secure specimens from the top, center, and bottom of the pile.

Method of Testing

Only a few kinds of tests were applied so that a greater number of samples would be available for each and because weather could not seriously affect many of the characteristics usually

[3] The weather during the period was typical of Pittsburgh, Pa.

determined. It might, however, lower their mechanical strength and thus decrease their resistance to abrasion, resistance to spalling, or crushing strength. Consequently, cold crushing tests were applied to each set of samples, selecting from six to eight in each case. It can be assumed that, with a given lot of brick, the resistance to abrasion and impacts, the strength in arches, and the strength under load at high temperatures would vary with the cold crushing strength.

This is also true for the resistance to spalling when one particular lot of bricks is under consideration. While thermal expansion, vitrification, grind and burn all have a relationship to spalling, these characteristics are constant for each brand and so the most important variable that might enter in this case appears to be a possible decrease in the strength of the bond. Spalling tests were made upon the fireclay brick, although they were omitted with the magnesia and silica brick because of the difficulty of obtaining significant results with these two types.

The spalling tests with the fireclay brick consisted in heating the specimens in the door of a furnace operating at 1350°C, partially immersing in a trough of running cold water for three minutes, air-drying, and repeating in hourly cycles. The bricks under consideration were particularly well bonded and hence the tests were discontinued after 25 partial immersions.

Results of Cold Crushing Tests

The figures given in Table II are expressed as end cold crushing strengths in pounds per square inch.

The average values are taken from six to eight determinations, a few of the results having been discarded when they showed abnormal deviation from the average.

TABLE II

END COLD CRUSHING STRENGTHS OF REFRACTORY BRICK AFTER EXPOSURE

Type		As received	After 6 months	After 12 months
	Maximum value	1418	1404	1109
	Minimum value	782	855	891
Fireclay A	Average value	1127	1114	1005
	Per cent average deviation	22.8	13.4	9.3

END COLD CRUSHING STRENGTHS OF REFRACTORY BRICK AFTER EXPOSURE

Type		As received	After 6 months	After 12 months
	Maximum value	1355	909	755
	Minimum value	545	545	545
Fireclay B	Average value	885	693	640
	Per cent average deviation	26.9	20.5	10.1
	Maximum value	2727	2245	1418
	Minimum value	1373	1327	909
Silica	Average value	1830	1680	1111
	Per cent average deviation	23.1	17.7	17.5
	Maximum value	5582	4255	3914
	Minimum value	3273	2726	2082
Magnesia	Average value	4464	3780	2978
	Per cent average deviation	14.5	12.7	17.4

Results of Spalling Tests

The following results also represent an average. It should be noted, however, that the bricks tested were unusually well bonded. This condition was not anticipated and the series should also have included bricks which fail after five, ten, and twenty immersions.

TABLE III

PER CENT SPALLING LOSS OF A AND B FIREBRICKS AFTER EXPOSURE AND 25 IMMERSIONS IN TEST

	As received	After six months	After twelve months
A	17	16	40
B	10	22	33

Discussion of Results

The crushing strength of the magnesia bricks decreased 15 per cent in six months and 33 per cent in twelve months. This decrease can safely be interpreted as representing still greater decrease in resistance to abrasion, construction stresses and spalling. When the original bricks were compared in the load test under a pressure of 25 pounds per square inch with those

which had been weathered for 12 months, the latter sheared at a temperature about 40°C lower. The magnesia bricks underwent the greatest percentage loss in strength,—a fact which explains the practice of protecting them carefully from the weather.

The decrease in the strength of the silica bricks was rather unexpected for they showed no outward signs of deterioration. Nevertheless, they lost 39 per cent of their original strength during the 12-month period. This condition is equally as, or more serious than, is the case with the magnesia bricks, for one of the greatest assets of silica bricks is their high strength, especially at working temperatures.

The fireclay bricks lost from 1 to 21 per cent in cold crushing strength after six months and from 11 to 28 per cent after twelve months. Additional samples of a third very strong brand of machine-made firebrick (C) were secured after six months. They had an original end crushing strength of over 5,000 pounds per square inch and showed practically no loss in strength after six months' exposure. On the other hand, some open porous hand-made bricks having an end crushing strength of only 500 pounds per square inch were practically worthless after six months' storage at a plant.

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POROSITY: VI. DETERMINATION OF POROSITY BY THE METHOD OF GAS EXPANSION *

By Edward W. Washburn and Elmer N. Bunting

ABSTRACT

Theory of the method.—The pore volume is measured by allowing the gas which fills the pores to expand into a measured volume and measuring the accompanying fall in pressure.

Applicability.—The method is in general applicable to pieces of any size and shape and to all classes of porous bodies or materials.

A new porosimeter.—For rapid work with shaped test pieces a new porosimeter is described. The new instrument measures accurately both pore volume and bulk volume. A complete porosity determination can be made in 5 minutes. No weighing is required. The results on ceramic bodies are reproducible to one unit in the first decimal place of the per cent porosity. Considerably higher accuracy than this can be secured if desired.

Results.—The results obtained with the new method are in all cases higher, in a number of cases very much higher, than those obtained by the methods of liquid absorption in current use. For fired bodies the same results are obtained with dry air, hydrogen or helium as the pore filling gas. The results show conclusively that complete filling of all the pores in a reasonable time can not be secured by any of the current methods using a liquid as the pore filling agent.

XVI. Introduction

53. Theory of the Method.—In the method described in the present paper a gas instead of a liquid is employed as the pore filling agent and its amount is determined by measuring the fall in pressure which accompanies a definite increase in its volume.[38] Owing to the low viscosity of gases this method is capable of yielding accurate results even for bodies with exceedingly fine

* Presented before a meeting of the Ohio Section, in Columbus, Nov. 19, 1921.

[38] The principle of this method was employed by Zehnder [*Ann. Phys.*, **10,** 40 (1903) and **15,** 328 (1904)] in an effort to perfect a rapid method for determining the true density of a material. For this purpose the results were not satisfactory from the point of view of accuracy. The extension of the method to the determination of porosity is of course obvious but does not seem to have been made heretofore.

pores where the liquid-absorption method either fails or requires recourse to high pressure apparatus. The new method possesses none of the drawbacks or sources of error of the liquid-absorption methods and in addition possesses a number of marked advantages of its own. The degree of accuracy attainable is greatly in excess of any practical requirement of ceramic testing.

54. Applicability of the Method.—The method is in general applicable to pieces of any shape or size, including granular material, and to all classes of porous bodies or materials whose bulk volume can be determined. Since no absorption liquid is employed, the piece under investigation is not injured or altered in any way during the determination. The method could thus be safely employed for determining the porosity of pieces of art pottery, archeological specimens or materials which might be injured by absorption liquids.

Two procedures will be described. The first one, which will be called the *General Method*, is applicable to pieces of any size or shape but is not so rapid as, and requires somewhat more elaborate apparatus than, the second method. The second method, which will be called the *Rapid Method* is designed for *shaped test pieces* and for rapid measurements in the laboratory or works.

XVII. The General Method

55. Apparatus and Procedure.—A flask or other suitably shaped vessel, B, of volume, V_1, is joined, by a capillary tube carrying a stop-cock, to the test vessel A, of volume V (see Fig. 7). To the vessel A is also attached a suitable manometer for measuring the pressure. The weighed piece or sample (W grams) of the dry material is placed in vessel A and, if maximum accuracy is required, the remaining unfilled portion of vessel A is filled with glass beads or rods of density D_g and mass m_g. The vessel A is then evacuated to some low pressure P_a (*e. g.*, 20 mm. Hg).

Flask B is filled with a non-adsorbable gas under suitable pressure. For most ceramic bodies dry air is a satisfactory gas but hydrogen will be required in some instances. (*Vide infra*, Sec. 69.) Helium could, of course, be employed for *all* types of porous materials at room temperatures or above. If a gas other than air is

used, the vessel A and the pores of the material under investigation must first be filled with this gas before evacuating vessel A to the pressure P_o.

The whole apparatus is now allowed to stand (preferably in a constant temperature bath, if maximum accuracy is desired) until temperature equilibrium is attained. The vessel B is then opened momentarily to the atmosphere in order to secure atmospheric pressure within it and is then closed again. When com-

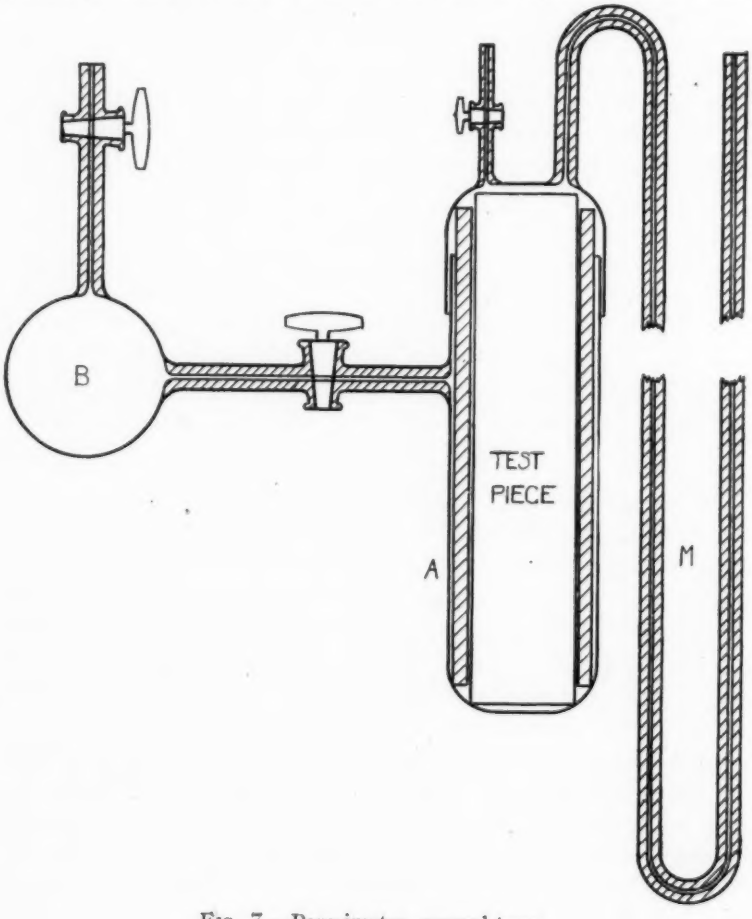

FIG. 7.—Porosimeter, general type.

plete temperature equilibrium is attained the manometer is read (P_o) and the stop-cock connecting the two vessels is then opened. When equilibrium is again attained the manometer is again read, P. The per cent porosity x can then be calculated from the relation

$$x = 100\left[\frac{(B-P)\ V_1}{(P-P_o)\ V_B} - \frac{V - m_g D_g - V_B}{V_B}\right] \qquad (14)$$

The bulk volume V_B, if not determined directly on the sample or piece used, is calculated from the relation $V_B = \frac{W}{D_B}$.

The functioning of the manometer should not appreciably affect the volume of the vessel to which it is attached or else the necessary correction should be applied. The method could obviously be used with the manometer attached to either of the two vessels and, if desired, the evacuation might be applied to vessel B instead of to vessel A. The formula for any of these arrangements and procedures is readily deducible from the gas laws.

56. Precision of Measurement and Principles of Design.— The best volume for the vessel B is that given by the expression

$$V_1 = \frac{100(V - m_g D_g) + (x - 100)\ V_B}{100} \qquad (15)$$

and under these conditions

$$P = \frac{B + P_o}{2} \qquad (16)$$

For a given sized test piece the accuracy of the measurement increases as the unfilled space in vessel A decreases. This is the reason for filling the space around the test piece with glass rods or beads as far as possible.

If the volume measurements are accurate to 0.01 cc. and the pressure measurements to 0.2 mm. of mercury, the total error in x will not exceed 0.1 unit for porosities up to 30 per cent and will not exceed 0.2 unit for higher porosities. Greater accuracy can be secured, if required, by proper design and care in measurement.

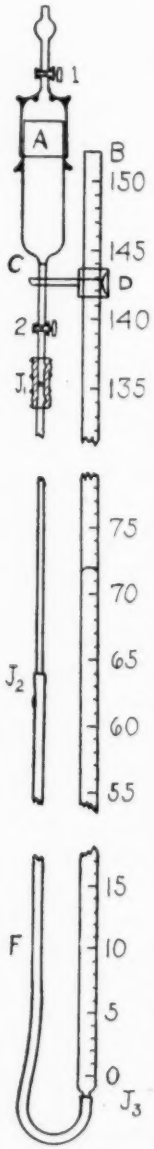

FIG. 8.—Rapid porosimeter.

Some control of temperature is essential for the most accurate work. Thus a variation of 0.5° in temperature between the initial and final pressure readings will produce an error of only about 0.1 unit in the computed porosity provided P_0 is not greater than about 20 mm. of Hg.

XVIII. The Rapid Method

57. The Apparatus.—A special apparatus called a *porosimeter* has been designed for rapid porosity determinations by the gas expansion method. The apparatus is designed primarily for use with shaped test pieces and is at the same time a simple and accurate volumeter and expansimeter. The bulk volume and the pore volume of the test piece are both directly measured and no weighing is required in any stage of the process.

The complete porosimeter is shown in Fig. 8. It consists of the porosity bulb A, connected by an impervious rigid walled flexible tube, F, to the burette B, which is provided with a movable reading arm, D. The burette tube is of uniform bore and is accurately graduated in *centimeters and millimeters*. Its internal cross-section should preferably be chosen so as to be close to one square centimeter or some even multiple or submultiple thereof.

58. Porosity Bulb Detail.—The details of the construction of the porosity bulb are shown in Fig. 9. This bulb consists of a vessel just large enough to admit an unfired test piece of standard dimensions. The hooks on the outside allow the cap to be held tightly in place by means of rubber bands or spring clamps. The small projections on the inside of the cap are for the purpose of preventing the closure of the outlet tube by the test piece as it is lifted by the admission of the mercury.

The cap and both stop-cocks must be well ground and fitted so that the bulb will hold a vacuum for at least 15 minutes without leakage greater than the equivalent of 0.1 mm. of mercury.[39] For bulk volume measurements only, where the highest accuracy is required, the porosity bulb may be provided with the side tube 3, for convenience in drawing off mercury. For most ceramic testing however, this side tube is an unnecessary complication.

The piece R (Fig. 9) is a solid glass rod, called the *reference piece*, whose volume V_R, is accurately determined by weighing it suspended in a liquid. Its purpose is explained below.

59. Setting up the Apparatus.—Clean the porosity bulb and burette with chrome cleaning mixture and dry. Lubricate all ground joints.[39] Connect the apparatus as shown in Fig. 8, and wire each connection tightly. Place the bulb and burette in their supports. Place in the porosity bulb the reference piece, R, whose volume V_R, is equal to $(1-s)V_d$ where V_d is the bulk volume of the test piece for which the porosity bulb is designed (cf. Sec. 67) and s is the maximum fractional shrinkage which must be provided for. Place the cap on the porosity bulb and secure it. Then raise the burette until its zero mark is on a level with stop-cock 1 (Fig. 9). Open both stop-cocks and pour clean mercury into the burette until the porosity bulb is full. Manipulate the apparatus until all bubbles of air caught between mercury and the tube wall have been removed.

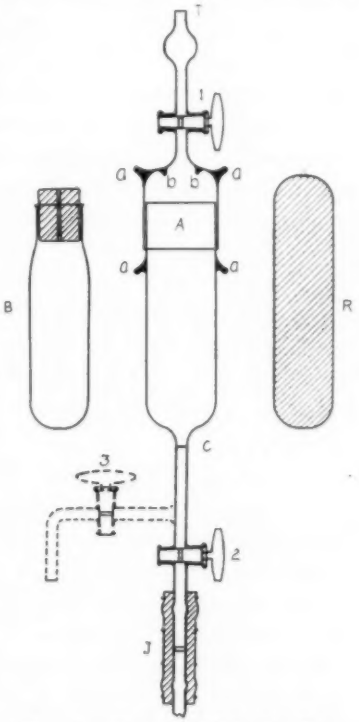

FIG. 9.—Porosity bulb detail.

[39] The sealing varnish and the lubricant previously described (see footnote 34) may be used as needed at these ground joints.

60. Determination of the Volume of the Porosity Bulb.—This determination, which needs to be made only once for a given apparatus, is conveniently carried out as follows: With the reference piece in place and both stop-cocks open, raise the burette until the mercury just fills the porosity bulb up to and into stop-cock 1. Close both stop-cocks and lower the burette until the mercury surface is approximately level with mark C (Fig. 9). Read the burette, R_1. Open stop cock 2, and lower the burette until the mercury level in the porosity bulb coincides with mark C. Close stop-cock 2 and raise the burette until the mercury surface is again approximately level with mark C. Read the burette, R_2. The difference between the two burette readings, R_2-R_1, is the free volume V_F, of the porosity bulb when the bulb contains the reference piece.

Open stop-cock 1 and remove the reference piece. Open stop-cock 2 and again raise the burette until the mercury level stands approximately at its zero mark. Close stop-cock 2, lower the burette until the mercury surface in it is on the level of mark C and read again, R_3. Now pour out the mercury in the porosity bulb until the level falls to mark C. Collect and weigh this mercury,[40] m_m grams.

The volume V, of the porosity bulb may now be computed, in burette-scale units, from the relation

$$V = V_F + \frac{V_R(R_2-R_3)\,D_m}{m_m} \qquad (17)$$

where D_m is the density of mercury at the room temperature prevailing.

61. Determination of the "Effective Barometric Pressure."—The "effective barometric pressure" B, is a quantity which is constant for a given piece of apparatus but is a function of the actual barometric pressure of the locality at the time the apparatus is being used. A value once determined can be employed as long as the barometer is constant. The determination is made as follows: Place the reference piece in the porosity bulb and secure the cap in place. With both stop cocks open, raise the burette until all the air is driven out of the porosity bulb. Close stop-cock 1.

[40] If the porosity bulb is provided with the side tube 3 (Fig. 9) this mercury can be more conveniently drawn off through this tube.

Lower the burette until the mercury level in the bulb stands at mark C. Clamp the burette, set the reading arm on the level of the mercury surface at C and read its position on the burette, R_c. Then read the position of the mercury surface in the burette, R_m.

$$B = R_c - R_m \tag{18}$$

It is evident that the determination of the effective barometric pressure is almost as simple an operation as reading an ordinary barometer. For a given bulb it differs from the true barometric pressure of the locality by a substantially constant amount of about a millimeter. This small difference, which is made up of the capillary pressure at C plus the pressure of a small amount of adsorbed air given off from the walls of the porosity bulb, cancels out in the numerator of equation (14), since the same effects are present to substantially the same extent in the subsequent operations with the test piece in place. In the computation, therefore, this "effective barometric pressure" should be used rather than the actual barometric pressure.

62. Preparation of the Test Piece.—The dried test piece is trimmed with a knife to the size for which the porosity bulb is designed, or until its dimensions are such that on burning it will shrink to this size or smaller.[41] After burning, it should be cleaned and trimmed as directed in Sec. 43. Unless the test piece has been in contact with water or with very damp air it is not necessary, with burned ceramic bodies, to dry the test piece previous to making the determination.

63. Determination of the Porosity.—With the test piece in place raise the burette until the mercury fills the porosity bulb up to some point within the bore of stop-cock 1. Read the burette, R_o. Then proceed exactly as in the determination of the effective barometric pressure. Before taking the final pressure readings, which will now be called R'_c and R'_m, wait until these readings

[41] If the porosity bulb is cylindrical in cross-section, somewhat greater accuracy can be secured in some instances (*Vide infra*, Sec. 67) by using test pieces with approximately octagonal cross-sections, which can be conveniently produced by shaving off the edges of the ordinary rectangular briquette after drying. For most practical purposes, however, the usual rectangular briquette will be quite satisfactory.

have become constant, adjusting the burette from time to time as may be necessary to make the mercury level in the bulb coincide with mark C With most ceramic bodies equilibrium will be attained in two or three minutes, but with certain bodies, containing a considerable volume of micropores, as much as 30 minutes may be required. If the mercury level at C remains constant for 3 minutes equilibrium may be assumed to have been attained and the final adjustment and readings may be made.

When R'_c and R'_m have been determined close stop-cock 2 and raise the burette until the mercury level in it is approximately level with mark C and read the burette, R.

If the walls of the flexible tube F (Fig. 8) are not compressed appreciably by the varying heights of mercury attained during the measurements

$$R=R'_m=R_m \tag{19}$$

and the determination of R and R'^m may be omitted. With a properly constructed flexible tube this will be approximately the case and for most practical purposes only the readings R_o and R'_c need be made. In any case if the relation (19) is found to be approximately but not exactly correct, small correction factors (which will be functions of the porosity) can be determined for each apparatus containing a given quantity of mercury and applied to the reading R_m in order to obtain R'_m and R thus obviating the necessity of making these two readings in each determination. The influence of these and all other small correction factors can also be eliminated by calibrating the whole apparatus as described in Sec. 65.

64. Calculation of the Porosity.—The per cent porosity is computed from the relation

$$\frac{x}{100}=\frac{[B-(R'_c-R'_m)](R-R_o)}{(R'_c-R'_m+\Delta)\ [V-(R-R_o)]} \tag{20}$$

The small capillary depression correction, Δ, is a constant for a given apparatus and may be determined as follows: With both stop-cocks open raise the burette until the mercury stands at mark C. The difference in the two mercury levels is the quantity Δ. Repeat several times and take the average. If the porosimeter

is calibrated, as described in Sec. 65, any uncertainty in the quantity Δ will be automatically taken care of by the calibration, and can have no influence on the result.

In equation (20) the quantity $R-R_o$, is the free volume, V_F, of the porosimeter and the quantity, $V-(R-R_o)$, is the bulk volume, V_B, of the test piece in burette scale units. If the porosimeter is provided with the side arm 3 (Fig. 9) these volumes can, if desired, be determined to a high degree of accuracy by drawing off the mercury through this side arm and weighing or measuring it. In that case the burette tube can be replaced by a simple leveling bulb and the pressures read by means of a cathetometer or a meter stick. (See Fig. 10.) This modified form of porosimeter construction while capable of somewhat greater accuracy requires more observations and more manipulations and is somewhat more expensive to construct. The simpler and more rapid form shown in Fig. 8 is therefore to be preferred for regular ceramic testing.

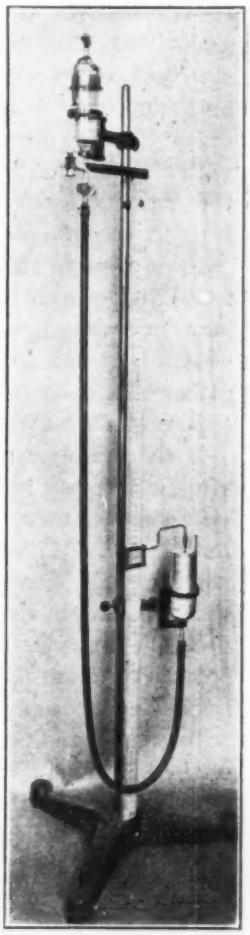

FIG. 10.

65. Calibration of the Porosimeter.—Like any other scientific measuring instrument the porosimeter should be calibrated over the region in which it is to be used, if results of the highest accuracy are desired. Calibration can also be made to take care of any uncertainty in the small Δ correction and of any small differences between R_m, R'_m and R, thus eliminating entirely two of the readings which would otherwise have to be taken during each determination (*Vide supra*, Sec. 63).

The calibration is made with the aid of the standard test piece B, Fig. 9. This test piece is a small bottle provided with a ground glass stopper having a fine capillary

opening through it. The bulk volume of the bottle and stopper is equal to that of the test piece for which the porosimeter is designed. (Cf. Sec. 67.) The bottle and stopper are accurately weighed, first empty and then filled with water at known temperature. Finally the bottle is filled with water, stoppered, and weighed suspended in water at known temperature. From these data the porosity, x_s, of this standard test piece can be accurately computed. Its porosity can also be varied between x_s and 0, by placing in it known weights of mercury. It is thus evident that by using such standard test pieces the porosimeter can be checked at any point on the porosity scale and a curve of corrections prepared, based either upon the procedure given in Sec. 63, or upon that procedure with the omission of the readings R'_m and R. From this curve the correction which must be applied to any measured porosity in order to obtain the correct value, can be read off directly.

From time to time it will be necessary to remove the mercury from the porosimeter so that both the mercury and the porosimeter may be cleaned. When the porosimeter is refilled, care should be taken to use always the same quantity of mercury, or rather that quantity of mercury which gives the same reading on the burette scale when the mercury in the bulb stands at mark C.

If the flexible connecting tube stretches appreciably under the varying mercury heights employed, the calibration correction will vary somewhat with the bulk volume of the test piece as well as with its porosity. With a properly constructed flexible tube this latter variation will, however, be entirely negligible. In any case its magnitude could obviously be determined, if desired. It is, of course, desirable to check a few points on the calibration curve occasionally.

66. Precision Discussion.—The precision attainable in the result depends upon the volume of the porosity bulb, upon the bulk volume and porosity of the test piece and upon the diameter of the burette and is calculable for any given case.

As an illustration of the precision attainable, a calculation will be made for the particular apparatus employed in the experiments described below. This apparatus was not designed to give the maximum attainable accuracy, but was designed to employ rectangular test pieces and to give all the accuracy required for ceramic bodies, other than highly vitrified porcelains.

The burette had a cross-section of one square centimeter. The green test pieces were rectangular briquettes 4 in. long and 1 in. square. The porosity bulb was approximately 100 cc. in volume.

In computing the precision attainable in x (equation 20) we will assume that each of the quantities, V, B, $R'_c - R'_m$, and $R - R_o$ can be measured with a precision of ± 0.5 mm. on the scale of the burette, a precision which is attainable with careful work.

By differentiating equation (20) separately with respect to each of these quantities and substituting the numerical values indicated, we obtain the following expressions for the separate effects:

For $V(=100$ cc.$)$, $\Delta_1 = 0.05$ cc. and

$$\Delta x_1 = \frac{-x\Delta_1}{V - (R - R_o)} = 0.001x \qquad (21)$$

For $B(=750$ mm.$)$, $\Delta_2 = 0.5$ mm. and

$$\Delta x_2 = \frac{x\{[V - (R - R_o)] + 100(R - R_o)\}}{B(R - R_o)} = \frac{(100 + x)}{750} \qquad (22)$$

For $R'_c - R'_m$, $\Delta_3 = 0.5$ mm. and

$$\Delta x_3 = \frac{x\{[V - (R - R_o)] + 100(R - R_o)\}^2}{100B(R - R_o)[V - (R - R_o)]} = \frac{(100 + x)^2}{150{,}000} \qquad (23)$$

For $R - R_o$ $(=50$ cc.$)$, $\Delta_4 = 0.05$ cc. and

$$\Delta x_4 = \frac{Vx\Delta_4}{(R - R_o)[V - (R - R_o)]} = \frac{x}{500} \qquad (24)$$

The total error in x arising from the combined effects of all four errors will on the average be equal to the square root of the sum of the squares of the separate errors. In Table VIII are shown the magnitudes of the separate errors and the total error for bodies of different porosities.

TABLE VIII

ILLUSTRATING THE ABSOLUTE ERROR IN THE COMPUTED PER CENT POROSITY, x, PRODUCED BY THE SEPARATE AND COMBINED ERRORS IN THE FOUR VARIABLES MEASURED

Per cent porosity, x	Separate effects due to the error in				Average total error
	V (=100 cc.)	B (=750 mm.)	$R'_c - R'_m$	$R - R_o$ (=50 cc.)	
0.1	0.0001	0.065	0.067	0.0002	0.09
.5	.001	.065	.068	.001	.09
1.0	.001	.067	.068	.002	.09
5.0	.005	.070	.074	.01	.10
10.0	.01	.073	.081	.02	.11
20.0	.02	.080	.096	.04	.13
50.0	.05	.10	.15	.10	.21
60.0	.06	.11	.17	.12	.24
80.0	.08	.12	.22	.16	.31
90.0	.09	.13	.24	.18	.34
100.0	.10	.14	.27	.20	.38

67. Principles of Design.—The precision attainable with the porosimeter may be controlled to a considerable degree by establishing the proper relation between the bulk volume of the test piece and the volume of the porosity bulb so as to produce the most favorable value for the free volume, V_F. If the bulk volumes of the test pieces are more or less fixed by other conditions, then for the highest precision a set of several porosity bulbs of different volumes should be available. With a given porosity bulb, however, the maximum precision can be secured by using a test piece of the proper bulk volume in each instance. This bulk volume is a function of the porosity to be measured and is obtained by subtracting from the volume of the porosity bulb, the most favorable value for the free volume, V_F, that is, the most favorable value for $R_o - R$ in equation (20). The most favorable value for $R_o - R$ may be computed from the equation

$$\Delta x = \sqrt{\Delta x_1^2 + \Delta x_2^2 + \Delta x_3^2 + \Delta x_4^2} \qquad (25)$$

where the quantities under the radical are those expressed by equations 21 to 24 inclusive, the most favorable value for $R_o - R$ being that value which makes the right hand member of equation (25) an arithmetic minimum. For practical purposes it will not be necessary to meet this condition very closely except when

working with bodies either of very high or very low porosity. In connection with the latter class of bodies some further discussion of this matter will be given in the next paper of this series.

68. The Rapid Porosimeter. Research Type.—It is obvious that minor details in the form and method of assembling the various parts of the rapid porosimeter are possible without changing the main principles of operation. The style described in the preceding pages was selected as probably the most desirable one for ceramic routine testing purposes in laboratory or plant. It is comparatively inexpensive to construct and to repair if accidently broken, easy to operate, and entirely satisfactory from the standpoint of accuracy. Indeed the errors in measurement will always be smaller than the variation in the porosity of different test pieces from the same lot, except possibly in the case of highly vitrified porcelains.

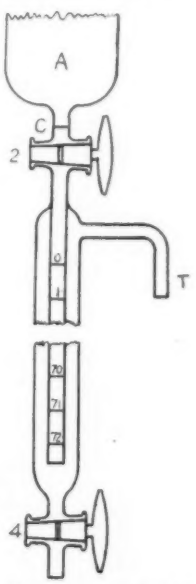

FIG. 11.—Rapid porosimeter, research type.

For research purposes, however, especially with non-ceramic materials, where still greater accuracy as well as absolute permanence of calibration are desired, an all-glass apparatus with no moving parts offers certain advantages. Such an apparatus is shown in Fig. 11. It is essentially the same apparatus as that shown in Fig. 8 but with the stem, S, of the porosity bulb lengthened and permanently sealed into the burette tube, B, and with the graduations (centimeters and millimeters) placed upon the stem, S, instead of upon the burette tube itself. *Such an amount of mercury is placed in the apparatus as to cause the meniscus in the burette tube to stand exactly at zero when the meniscus in the stem stands exactly at mark C.*

The apparatus is operated as follows: With the test piece in place and stop-cocks 1 and 2 open, apply air pressure at T until the porosity bulb is filled. Close stop-cock 2 and release the air pressure so as to leave T open to the atmosphere. Open stop-cock 2 until the mercury stands in the center of the bore of stop-

cock 1. Then read the burette. This reading determines the free volume, V_F, and hence also the bulk volume, V_B, of the test piece in burette scale units.[42]

The pressure reading is now determined as follows: Close stop-cock 1, open 2 and with the aid of 4 draw off mercury until the meniscus stands a little above mark C. When equilibrium is reached adjust until the meniscus stands exactly at mark C and read the position of the mercury surface in the burette tube.

The porosity can now be calculated from these two readings, the constants of the apparatus, and the effective barometric pressure. The effective barometric pressure is determined in the same way as the pressure reading just described, but with the reference piece substituted in place of the test piece. All mercury drawn off through stop-cock 4 must be carefully returned to the apparatus after removing the test piece. This is also true of any mercury accidentally removed with a test piece. The amount of mercury in the apparatus must be kept constant or else an additional reading will be required each time. The whole apparatus can be calibrated in the manner described in Sec. 65, and such calibration will be permanent.

The precision of the volume readings depends upon the relative diameters of the stem and the burette tube and can obviously be made as great as desired.

The advantages of this style of apparatus over that of Fig. 8 are obvious. It is, however, more expensive to construct and requires a supply of compressed air for its operation, although the latter might be replaced by a leveling bulb attached below stop-cock 4, if desired.

69. Experimental Results.—In order to compare the results obtained by the gas expansion method with those given by the method of liquid absorption, fifteen test pieces of various porosities were studied. The porosity of each piece was first measured in the porosimeter, using in successive experiments; (1) air from the room, (2) dry hydrogen and (3) dry helium, respectively, as the pore filling gas. In introducing the last two gases the porosim-

[42] If these volumes are desired in cubic centimeters, it is only necessary to multiply by the appropriate factor for converting burette scale units into cc. This is not necessary, however, if the porosity only is required.

eter containing the test piece was first evacuated to a high vacuum and the pure gas then admitted until atmospheric pressure was attained.

After completing the measurements in the porosimeter, test piece No. 6 was boiled for 5 hours in distilled water at atmospheric pressure and weighed. Test pieces 4, 6, 10, 11 and 12 were then saturated with water at room temperature by the vacuum procedure of Section 47 above. After weighing, these test pieces were then dried in vacuo at 100°, followed by a short calcination at red heat. All 15 pieces were then saturated with vaseline at 200° using the procedure of Section 47. The results obtained together with the soaking times employed are shown in Table IX.

TABLE IX

COMPARATIVE RESULTS OBTAINED BY THE "GAS-EXPANSION" AND THE "LIQUID-ABSORPTION" METHODS OF DETERMINING THE POROSITY OF CLAY WARE. FIRST NINE BODIES FIRED TO CONE 10, NEXT THREE TO CONE 03 AND LAST THREE DRIED AT 120°C BUT NOT FIRED

Test piece no.	Body	Per cent porosity with pore filling fluid					
		Air	H_2 or He	Water	Hours soaking	Vaseline	Hours soaking
1	Stoneware	13.9	13.9	...	..	11.9	3
2	Stoneware	19.2	19.2	...	..	18.2	3
3	Stoneware	36.4	36.4	...	..	34.6	2
4	Stoneware	12.2	12.2	9.3	90	1.2 8.4	24 120
5	Stoneware	23.8	23.8	...	..	21.5	18
6	Stoneware	15.6	15.6	14.8[1]	24	2.3 13.5	2 120
7	Stoneware	15.4	15.4	...	..	12.4	18
8	Stoneware	15.8	15.8	...	..	10.7	18
9	Fire Clay	26.4	26.4	...	..	24.2	18
10	Red Clay	35.3	35.3	32.0	24	32.0	24
11	Red Clay	37.1	37.1	31.7	24	32.0	24
12	Red Clay	34.4	34.4	31.0	24	31.0	24
13	Stoneware	32.4	30.2	...	..	27.2	45
14	Red Clay	36.2	34.2	...	..	27.0	45
15	Red Clay	36.2	34.2	...	..	26.8	45

70. Discussion of Results.—Helium is known to be not adsorbed appreciably at room temperature. The identity of the results obtained with the fired bodies in the case of all three

[1] Test piece No. 6 on boiling in water for 5 hours at atmospheric pressure and weighing gave a porosity result of only 3 per cent.

gases shows, therefore, that no appreciable error from adsorption is to be feared in using air in the porosimeter for porosity measurements with this class of bodies. With the unfired bodies, however, the results obtained with air indicate that small but appreciable quantities of air are adsorbed. Some of this air is given off in the porosimeter thus causing too high results. With hydrogen and helium on the other hand identical results were obtained, thus showing that hydrogen may be safely employed as the pore filling gas when results of high accuracy are desired with unfired bodies. For most practical purposes, however, an accuracy of one unit in the per cent porosity of unfired bodies is ample and this could probably be secured by applying a definite percentage correction to the results obtained with air, the magnitude of this correction being obtained by means of a sufficiently extensive study of various types of unfired bodies using both air and hydrogen as pore filling agents.

The results obtained with the absorption liquids are, in all cases, appreciably lower than those obtained with the gases and the importance of a long soaking period is evident, thus showing, especially in certain cases, the presence of a considerable volume of micropores which are filled with extreme slowness by the liquids. In the case of test piece No. 4 the presence of these very fine pores was apparent even when using the porosimeter since it required nearly 30 minutes for the gas to issue from all of these pores and equalize the pressure. In other words, a constant value for R'_m was not reached until half an hour had elapsed. With test pieces Nos. 1, 2, 3, 5, 9 and 10 there is fair agreement between the results of the gas expansion method and those of the liquid absorption method (although the former are in all cases higher) and this agreement could be bettered by employing longer soaking times or higher pressures. These bodies evidently do not contain any considerable volume of micropores and with such bodies the liquid absorption method will be reasonably reliable, although the soaking time should be greatly increased over what has been the practice in the past or high pressures should be employed.

71. Bodies with Large Pores.—For determining the porosity of bodies, such as "Non-pareil" brick, having very large pores, the porosimeter is not suitable since all such pores on the surface

of the test piece would be filled by the mercury. By filling the surface pores with paraffine, however, the bulk volume of the test piece could be accurately determined and such a determination combined with the data secured from a previous measurement of the total pore volume by means of the *General Method* (Sec. 55) would give an accurate value for the porosity. In other words the gas expansion principle, as employed in the *General Method*, is applicable to any body for which the bulk volume can be determined by any suitable procedure.

72. Bodies of Very Low Porosity.—The use of the gas expansion method for highly vitrified bodies will be discussed in the next paper of the series where the results of some studies of electrical porcelain will be presented.

XIX. Conclusions

73. Advantages of the Gas Expansion Method.—(1) It will give correct results even in the case of bodies containing a very considerable volume of micropores or of pocket pores (Cf. Sec. 3) with narrow openings. (2) It is not necessary to dry or to weigh the test pieces at any stage of the process. (3) In its general form the method is applicable to bodies of any size or shape (including granular material) provided the bulk volume or bulk density of the body or material is known or can be determined. (4) Since the method employs no pore filling liquid it does not injure or alter the test piece or material in any way. (5) In its rapid form the method is sufficiently rapid for all practical purposes. If a number of test pieces are to be measured, the average time consumed in a complete determination of the porosity is, per test piece (*a*) 2 to 3 minutes for an accuracy of one unit in the result or (*b*) 5 to 10 minutes for an accuracy of 0.1–0.3 unit in the result. (6) The method seems to be entirely suitable both as a practical engineering method and as a *standard reference method* for *all* classes of bodies.

74. Acknowledgment.—We desire to express our appreciation of the kindness of Dr. R. B. Moore of the U. S. Bureau of Mines in supplying us with a cylinder of pure helium for use in the experiments recorded in Sec. 69.

(*To be continued*)

JOURNAL AMERICAN CERAMIC SOCIETY

Preparation of Abstracts

Every article in THIS JOURNAL is to be preceded by an abstract prepared by the author and submitted by him with the manuscript. The abstract is intended to serve as an aid to the reader by furnishing an index and brief summary or preliminary survey of the contents of the article; it should be suitable for reprinting in an abstract journal so as to make a reabstracting of the article unnecessary. The abstract should, therefore, **summarize all new information completely and precisely.** Furthermore, in order to enable a reader to tell at a glance what the article is about and to enable an efficient index of its subject matter to be readily prepared, the abstract should contain **a set of subtitles** which together form a **complete and precise** index of the information contained in the article. This requires at least one and often several subtitles even for a short abstract.

In the preparation of abstracts, authors should be guided by the following rules, which are illustrated by the abstracts in THIS JOURNAL for February and March, 1921.* The **new information** contained in an article should first be determined by a careful analysis; then the subtitles should be formulated; and finally the text should be written and checked.

Rules

1. **Material not new** need not be analyzed or described in detail; a valuable summary of a previous work, however, should be noted with a statement indicating its nature and scope.

2. **The subtitles should together include all the new information;** that is every measurement, observation, method, improvement, suggestion and theory which is presented by the author as new and of value in itself.

3. **Each subtitle should describe the corresponding information so precisely** that the chance of any investigator being misled into thinking the article contains the particular information he desires when it does not, or vice-versa, may be small Such a title as "A note on blue glass," for example, is evidently too indefinite a description of information regarding "Absorption spectra of glass containing various amounts of copper-cobalt and chromium-cobalt." General subtitles, such as "Purpose" and ' Results" should not be employed as they do not help to describe the specific information given in the article.

4. **The text should summarize the authors' conclusions and should transcribe numerical results of general interest,** including those that might be looked for in a table of physical and chemical constants, with an indication of the accuracy of each. It should give all the information that anyone, not a specialist in the particular field involved, might care to have in his note book

5. **The text should be divided into as many paragraphs as** there are distinct subjects concerning which information is given, but no more than necessary. All parts of subtitles may be scattered through the text but the subject of each paragraph, however short, must be indicated at the beginning.

6. **Complete sentences** should be used except in the case of subtitles. The abstract should be made as readable as the necessary brevity will permit.

7. **The** ms. of all abstracts must be typewritten and double or triple spaced.

* The rules were prepared by the Research Information Service of the National Research Council. The Society is indebted to Dr. G. S. Fulcher of the Corning Glass Works (formerly with the National Research Council) for the rules and the illustrative abstracts.

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Ceramic Abstracts

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[1] The abbreviation (*C. A.*) at the end of an abstract, indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

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General and Miscellaneous

1. The utilization of red slime. OSKAR LECHER. *Tonind. Ztg.*, **45,** 1023(1921).—In the manuf. of $Al(OH)_3$, bauxite is mixed with a soln. of NaOH and heated to 160–170°C in an autoclave under a pressure of 3–4 atms. or is fused with soda. In each case an easily sol. $Na_3Al_2O_3$ is formed which is removed by filtration. A red slime containing Fe_2O_3, SiO_2, TiO_2 and MgO remains in the filter press and is very abundant as a by-product. In one case this slime had the following compn.: H_2O 7.8%, loss on ignit. 12.3%, SiO_2 11.0%, Fe_2O_3 50.9%, CaO 8.2%, MgO tr. and TiO_2 0.23%. This material has been successfully substituted for Fe_2O_3 as a coloring oxide in glazes. By using the following mixt. a beautiful light green was obtained: 75.5 flint, 21 $CaCO_3$ and 0.7 red slime. By using 1.4 grs. of slime a dark green was obtained. With increasing amts. browns were obtained. By adding varying amts. of this slime to light burning clays many shades of red ware may be produced.

H. G. SCHURECHT

2. Poured molds versus pressed molds. ANON. *Tonind. Ztg.*, **45,** 982–83 (1921).—Plaster molds made under pressure are much stronger and more durable than those made by casting. Pressed molds are more suitable for molding tough bodies and where considerable pressure is used in molding, while the cast molds are more suitable for casting clay wares. H. G. S.

3. The proper lubrication of ball bearings. H. BURRIE. Société des Roulements á Billes SKF. *Industrie chimique*, **8,** 276–77(1921).—The function of lubrication in ball bearings is the protection against corrosion and facilitating the longitudinal motion of the journal when such is required. The lubricant must be free from acids and alkalies (max. 0.1%), lime (max. 0.5%), resins, and all traces of impurities which might cause friction. The best lubricant is a high grade oil of suitable viscosity (depending on the nature of the work). If grease is used it must not melt at the temp. of the bearing. Graphite should never be used for lubricating ball bearings. Simple tests for detecting acidity, alkalinity, and resins, and for detg. m. p. are given. A. P.-C.(*C. A.*)

4. Dental ceramics: a treatise on the technic of porcelain manipulation. FRED R. FELCHER. *Dental Cosmos*, **63,** 387–94, 483–88, 624–32, 681–87(1921).—A comprehensive survey of the entire field. JOSEPH S. HEPBURN (*C. A.*)

5. Internal friction of liquids under high pressure. O. FAUST. (Cf. *C. A.*, **8,** 1373).—The detn. of the compressibility of lubricating oils under high pressure, and the application of the results to the tests of a high-pressure viscosimeter to obtain the values of the viscosities of the oils. J. H. HYDE. The detn. of certain physical properties of the oils used in the Lanchester worm gear experiments. ANON. Testing the viscosity of oil at high pressure. CHARLES A. PARSONS. Variation in the efficiency of a worm gear due to the differences in the lubricant employed. J. H. HYDE. An app. for the detn. of the absolute viscosities of liquids at high pressures and the results obtained with it for certain lubricating oils. J. H. HYDE. App. for the examn. of the viscosity of oils under any pressure. C. V. BOYS. Description of the oil-testing app. designed by R. M. Deeley. ANON. (Cf. *C. A.*, **14,** 1475.) Précis of report

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6. The improvement of the lubricating properties of mineral oils. J. H. HYDE. *Engineering*, **111**, 708–709(1921).—Tests made on the Deeley friction testing machine (cf. preceding abstract) and the Lanchester worm gear machine (cf. *C. A.*, **14**, 1475) prove that, on adding oleic and other organic acids to a mineral oil, a very considerable reduction in the static friction is produced. So little as 0.1% of fatty acid effects a very considerable reduction; oleic acid, acid rape oil and the rape oil fatty acids all having similar effect. The Lanchester machine shows a gear efficiency of 96.0% with straight mineral oil; on adding 0.2% of oleic acid the efficiency is raised to 96.4%.

EUGENE C. BINGHAM (*C. A.*)

7. Human waste in industry. HARRY E. MOCK. *Chem. Met. Eng.*, **25**, 369–74(1921).—A symposium. (*C. A.*)

8. Industrial benefits of research. CHARLES L. REESE AND A. J. WADHAMS. *Nat. Research Council, Reprint Circ. Series*, **18**, 13 pp.(1921).

E. H. (*C. A.*)

BOOKS

9. Les Colloides: Leurs gelées et leurs solutions. P. BARY. Paris D. 47 and 49 Grands Augustins. 508 pp. 50 fr. For review see *Rev. prod. chim.*, **24**, 538 (1921). (*C. A.*)

10. Report of the lubricants and lubrication inquiry committee. *Dept. of Scientific and Industrial Research. Advisory Council. H. M. Stationery Office*, 1920, 126 pp. S. DONKIN, Chairman. The report reviews existing knowledge of lubrication and suggests several lines along which research is needed. The following appendices are part of the report. Internal friction of liquids under high pressure. O. FAUST. (Cf. *C. A.*, **8**, 1373). The detn. of the compressibility of lubricating oils under high pressures, and the application of the results to the tests in the high-pressure viscosimeter to obtain the values of the viscosities of the oils. J. H. HYDE. The detn. of certain physical properties of the oils used in the Lanchester worm gear experiments. ANON. Testing the viscosity of oil at high pressure. CHARLES A. PARSONS. Variation in the efficiency of a worm gear due to the differences in the lubricant employed. J. H. HYDE. An app. for the detn. of the absolute viscosities of liquids at high pressures and the results obtained with it for certain lubricating oils. J. H. HYDE. Description of oil-testing app. designed by R. M. Deeley. ANON. (Cf. *C. A.*, **14**, 1475.) Précis of report by T. C. Thomsen

on the cup-and-ball viscosimeter designed by Michell. ANON. Report on tests made in the Lanchester worm gear testing machine on three samples of aircraft oils. J. H. HYDE. Rept. on the characteristics of the flow of oil over a journal bearing. J. H. HYDE. Memorandum on J. H. Patterson's suggested method for preventing the sepn. of oil emulsions when mixed with salt water. ANON. Results of examn. of a sample of "Aliphol Omnium" compounding medium for lubricating oils. ANON. Trials of "Oildag" in aero engines by the Air Ministry. D. R. PYE. Detn. of the frictional coeff. of shaft bearings (plummer blocks) using a lubricant with and without the addition of "Oildag."

EUGENE C. BINGHAM (*C. A.*)

Apparatus and Instruments

11. Modern filtering apparatus. HERMANN RABE. Charlottenburg. *Chem. Ztg.*, **45,** 501–504, 532–34(1921).—Brief descriptions, with 14 cuts, of the Kelly and Sweetland filter-presses, of the de Häen, Plausen and Passburg ultra-filters, of vacuum filters, hydraulic presses, Heine centrifugals, sand filters, filters with air pressure, and the special H_2O-purification Berkefeld and Hansa filters.

J. H. MOORE (*C. A.*)

12. Study of the fundamental laws of filtration using plant-scale equipment. FRED P. BAKER. *J. Ind. Eng. Chem.*, **13,** 610–12(1921).—Theory, derivation and practical application of W. K. Lewis' fundamental filter equation are discussed. Tests were made on com. filter presses to study the filter equation and to det. consts. for defecated sugar solns. The use of the equation in designing filters is shown. For sludges containing compressible solids a constant rate of flow through filter is markedly superior to operation under const. pressure.

A. R. ALBOUZE (*C. A.*)

13. Viscosimeters. F. WILBUR SHULENBERGER. *Paint, Oil, Chem. Rev.*, **72,** No. 3, 10–11, 13–14(1921).—There is a general discussion of the measurement of viscosity and a brief description of the following types of viscosimeters:—Scott, Engler, Redwood, Saybolt Universal, Saybolt Furol, Gardner and Holdt Bubble, Stormer, and Doolittle.

EUGENE C. BINGHAM (*C. A.*)

14. Constant-temperature baths. "OMEGA." *Chem. Trade J.*, **69,** 30 (1921).—A list is given of 15 mixts. for const.-temp. baths and requiring little attention for boiling temps. from 40° to 300°. For the lowest temp. a mixt. of 98% EtBr and 2% EtOH is used and for the highest temp. 90% cottonseed oil and 10% beeswax.

W. H. BOYNTON (*C. A.*)

15. The pyrometer from the standpoint of the user. ARTHUR N. ARMITAGE. *Trans. Am. Soc. Steel Treat.*, **1,** 651–53(1921).—Practical suggestions of construction, standardization and operation. An elec. weld gives better results than an acetylene weld for couples. Dry fire clay in the protecting tubes increases the life of iron-constantan couples.

W. A. MUDGE (*C. A.*)

16. A new centrifugal filter press. C. R. PLATZMANN. *Tonind. Ztg.*, **45,** 1081–82(1921).—A new centrifugal filter press made by Stancourt Sons and Muir Ltd., Lon. is described. The substance to be filtered is thrown with

great force against a filtering medium with a pressure as high as 1 kg./cm.^{2}. When filled the machine is stopped and the clay is easily removed by raising the outer shell of the press. H. G. SCHURECHT

17. Sandwasher. L. SCHMIDT. *Tonind. Ztg.*, **45,** 1047–48(1921).—The Bavaria Machine Co., Schwaben, make a sand washer in the form of a hexagonal rotary screen. The sand is fed in at one end while water forced in at the other washes the impurities thru the screen. Sands containing as high as 60% clay may be thus washed. The washer occupies little space and can therefore be operated indoors. H. G. SCHURECHT

18. Carbon dioxide indicator of simple design and rugged construction. ANON. *Elec. Rev.* (Chicago), **79,** 218(1921).—The instrument worked by a minute jet of steam continuously aspirates gases from the flue to which it is connected. The gas drawn through an Al filter passes into a chamber of the indicator with a porous pot inside contg. a dry reagent. A pipe connects the chamber with a vessel contg. water into which dips one end of a second pipe, the other end of which is taken into the porous pot. Some gas penetrates into the interior of this pot and is absorbed by the reagent, causing partial vacuum and the colored liquor rises in the glass tube calibrated in percentages of CO_2, which may be read at considerable distance. Renewal cartridges inserted once in 24 hrs. maintain the instrument in continuous operating condition. L. C. KRUEGER (*C. A.*)

19. Methods for measuring large volumes of gas, especially applicable to gas plants or coke ovens. C. BERTHELOT. *Rev. metal.*, **17,** 668–76(1920).—B. describes briefly, giving advantages and disadvantages, the methods for measurement by means of a gasometer, by the Pitot tube, by the Lecocq method which is based upon the detn. of the exact vol. of air admitted to the furnace for combustion of the gas, of the vol. of gas drawn out by the exhauster, of the NH_3 in the gas and in the wash water, and at some length, the Murgue method which is based upon the measurement of the loss in pressure caused by a diaphragm inserted in the gas main, the difference in pressure on the opposite sides of the diaphragm being measured by a manometer. The app. is very exact, measuring variations within 0.01 mm. J. L. WILEY (*C. A.*)

20. Mill for colloidal comminution in industrial chemical work. C. NASKE. *Z. Ver. deut. Ing.*, **65,** 495–96(1921); cf. *C. A.* **15,** 1584.—The characteristics and importance of org. colloids as regards plant nutrition, and of inorg. colloids as regards *ceramics*, colors, photography, etc., are discussed. Methods of prepg. dispersions may be either by elec. or mechanical means. A hammer mill has the disadvantages that an increase in speed increases the air resistance; much heat is evolved to no purpose; and the finest particles, which should be further subdivided, escape the beaters and are carried through the gratings with the air stream. A ball mill has the disadvantages that the velocity of fall of the balls is small, the work done per blow small and the number of blows few. Hence, an impractical length of time is required for colloidal comminution, Plauson's "Colloidmill" first made possible the mechanical prepn. of dispersoids on a large scale by modifying a hammer mill so that the beater arms impinged

on a liquid surface. P. further operated the rotor at very high peripheral speed to increase the number of blows per unit of time. Two cross-sections of the mill are shown. It consists of a water-cooled cylindrical casing with axis horizontal, and on eccentrically mounted rotor whose projections work past similar projections fixed on the casing and on an adjustable bottom bed plate. When the rotor is operated at high speed the liquid is flung off the rotor and again sucked in bringing fresh particles into contact. The centrifugal force also sets up a rotation of the liquid in the casing. The suspension to be ground enters at the top and is discharged at the bottom of one side. A very powerful hammering action is obtained. Heat and elec. effects assist in the comminution, the latter tending to keep the fine particles sepd. Difficulties as regards shaft packing and strength of parts have been partially overcome, the latter by using "spring steel plate." A fineness of 0.3μ is obtained at 20, of 0.1 μ at 30 and colloidal size at 40 m. per sec.

C. C. HERITAGE (*C. A.*)

Chemistry, Physics and Geology

21. The equilibrium diagram of the iron-silicon system. TAKEJIRÔ MURAKAMI. *Science Reports Tôhoku Imp. Univ.*, **10**, 79–92(1921).—By means of magnetic and thermal analyses, as well as microscopic observation, the Fe-Si alloys contg. less than 32.7% of Si are thoroughly investigated, and the equil. diagram obtained by Guertler and Tammann is revized. In this system, 2 compds., Fe_3Si_2 and FeSi, are found. The former is magnetic, with its critical point at 90°, while the latter is non-magnetic. F. P. PHELPS (*C. A.*)

22. A new heating microscope for high temperatures : with synchronous revolving nicols. K. ENDELL. Berlin. *Z. Krist.*, **56**, 191–93(1921).—Description of a relatively simple app., made by Leitz. It is useful in detg. m. ps., in observing sintering in Portland cement mixts., ore-flux mixts., etc., and in the study of changes in glasses and enamels. E. T. WHERRY (*C. A.*)

23. Water content of heulandite. K. H. SCHEUMANN. *Ber. Ver. Sachs.* **73**, 3–113(1921).—The results of this elaborate study are shown in the figures of 18 analyses, 15 charts of curves, and hundreds of detns. of H_2O in the mineral under different conditions, the figures of which are assembled in more than 15 tables. (*C. A.*)

24. The colloidal system of silica-alumina. J. SPLICHAL. *Chem. Listy*, **15**, 53–56, 88–90, 110–13, 140–43, 164–67(1921).—The following observations were noted during the expts.: The hydrosols, silica and alumina, ppt. each other. Even if the colloidal particles at certain conditions of concn. fail to ppt. and settle out, then the viscosity and the opalescence of the mixt. of hydrosols are to be considered as evidence of the beginning of coagulation in the system. The opalescence is caused by the dispersion phase, which septs. first in a solid form. In these cases the solid phase always remains dispersed, does not settle out and its quantity is not increased with time. In the same manner Freundlich (cf. Ishizaka, *C. A.*, **7**, 2878) and Paine (*Kolloid. chem. Beihefte*, **4**, 24(1912–13)) found that in order to obtain a measurable

coagulation in simple hydrosols, the added electrolyte must be present in a certain definite concn. The pptn. is due only to the reciprocal action of the hydrosol particles. The electrolyte, present in the hydrosols in very small concns. has no effect on the pptn.; the viscosity is decreased. The pptn. is most rapid and the viscosity is greatest in a hydrosol mixt. in which the concn. ratio of Al_2O_3 to SiO_2 is 1:3. The prepn. of the alumina hydrosol from com. Al acetate according to the procedure of Crum (*Ann.*, **89**, 156(1854); *J. prakt. Chem.*, **61**, 90(1854)) did not prove successful owing to the presence of small amts. of H_2SO_4 in the Al acetate. H_2SO_4, even in very small amts., coagulated the alumina hydrosol. To avoid this, S. prepd. the Al acetate by the action of pure $C_2H_4O_2$ on pure Al. The excess of $C_2H_4O_2$ was removed by steam distn.

JOHN M. KRNO (*C. A.*)

25. Boron and silicon chemistry. Experimental investigation of very volatile material. ALFRED STOCK. *Ber.*, **54A**, 142–58(1921).—This is a resumé of S.'s very numerous contributions to the knowledge of the properties of B and Si. A subject index to the articles in which the various parts of S.'s vacuum app. are described is included. To those interested in this field this resumé will be of great value as a means of ready reference to S.'s already voluminous publications.

A. R. MIDDLETON (*C. A.*)

26. Industrial electrosmosis. F. ROWLINSON. *Beama*, **8**, 341–45(1921).—Clay treated by the electrosmose process is remarkably fine and plastic.

C. G. F. (*C. A.*)

27. Plasticity of clays. J. W. MELLOR. *Trans. Faraday Soc.*, **1921**, May 31 (adv. proof).—M. discusses the theory of the plasticity of clay from the standpoint of physical and mechanical properties, and also the relative value of the factors involved in proposed formulas for plasticity detn. An app. is described for measuring plasticity by means of forming spheres of standard size and applying pressure until outside cracks appear. In consideration of plasticity, he discusses grain size of clay, effect of acids, alkalies and salts on sedimentation, and the action of colloidal matter. Directions are given for isolating colloidal clay by suspension and evapn.

RUSSELL M. JONES (*C. A.*)

28. Thermal expansion of some substances. I. KARL SCHEEL. Phys. Tech. Reich. *Z. Physik*, **5**, 167–72(1921).—The measurements are made by a direct method for large specimens and by a Fizeau dilatometer for small ones. Values are given from $-190°$ to $+500°$ for Al, Mg, Ag, *quartz, porcelain and some Jena glasses*, and from $-190°$ to $+100°$ for invar and some other special alloys. **II.** J. DISCH. Phys. Tech. Reich. *Ibid.*, 173–75.—D. measures with a Fizeau dilatometer the values for Cr, Mn, Mo, Ni, Ta, W, and "Elektron."

F. C. HOYT (*C. A.*)

29. Progress of colloidal chemistry in ceramics since the end of the world war. H. ARNOLD. *Kolloid-Z.*, **29**, 105–106(1921). E. J. C. (*C. A.*)

30. Calcium silicide—a new deoxidizing agent. W. S. ANDERSON. *Raw Material*, **4**, 51–52(1921).—$CaSi_2$ performs 2 principal functions when added to a molten bath of iron or steel: (1) as a deoxidizing agent, (2) as a reheater.

In performing function (1) it combines with O forming $CaSiO_3$, which rises to the top of the bath in a manner similar to all slags and leaves no harmful inclusions in the metal. The reaction is extremely vigorous, hence, its reheating power. H. C. PARISH (*C. A.*)

31. The equilibria of permutites. F. W. HISSCHEMÖLLER. Univ. Technique, Delft. *Rec. trav. chim.*, **40,** 394–432(1921). (*C. A.*)

32. Ultramarine pigments. AUGUST CHAUDET. *Anales soc. quim. Argentina*, **8,** 100–4(1920).—C. cites the following expts. to support the belief that the ultramarines are solid solns. of S. If kaolin be treated with a hot concd. soln. of Na polysulfide a blue color is produced. By using either natural or artificial NaAl silicate instead of kaolin a much more intense blue is produced. If to a boiling concd. soln. of Na polysulfide an excess of dry hydrated silica be added an intense blue or violet color is produced. Slaked lime and cold concd. Na polysulfide give a blue or green color, $Mg(OH)_2$ gives the same result and so does dry starch. L. E. GILSON (*C. A.*)

33. Melting and boiling point of minerals. II. L. H. BORGSTRÖM. *Öfvers Finska Vetensk. Soc. Förh.*, **59,** A, No. 16, 14 pp.(1917); continuation of *C. A.*, **9,** 2364.—For practical purposes the ratios between the b. ps. of liquids, on the abs. scale, are the same at all pressures. Using Cl_2 as a standard of reference, this relation is shown to hold for a number of org. and inorg. substances. Extending the method to substances of geological interest, the approx. b. p. is calcd. for 14 minerals at 93 atm. pressure. E. T. W. (*C. A.*)

34. White clays and bauxites of central Georgia. ANON. *Chem. Met. Eng.*, **25,** 672(1921).—The Cer. Exp. Sta. of the U. S. Bur. of Mines located at Columbus, Ohio, has entered into a coöperative agreement with the Central of Georgia R. R. through its industrial agent, J. M. Mallory, and its president, William A. Winburn, whereby the Cer. Sta. is to investigate the white clays and bauxites along the right of way of the R. R., the lines of which pass through about 80 % of the white clay and bauxite belt of Ga. H. F. S.

35. The clays of the Tandil Mts., Argentine Republic. M. A. ZAMBONI. *Anales soc. quim. Argentina*, **8,** 190–99(1920).—Complete phys. and chem. analyses of several clays are given. L. E. GILSON (*C. A.*)

36. Graphite ore-deposits in Norbergs Bergslag. GUSTAF T. LINDROTH. *Geol För. Förh.*, **40,** 27–76(1918).—The history and production of the graphite deposits are reviewed, and their geology and petrography described in detail. E. T. W. (*C. A.*)

37. Some American dolomites. BURLEIGH B. REED AND NICHOLAS KNIGHT. *Proc. Iowa Acad. Sci.*, **26,** 377–78(1919).—Typical specimens of rock used for building stones in their respective localities were obtained in order to make a comparison of their chem. compns. Following are results of analyses: (1) From Mt. Vernon, Iowa; Niagara formation; yellowish gray, due to Fe. SiO_2 1.29, $Fe_2O_3+Al_2O_3$ 0.57, $CaCO_3$ 55.17, $MgCO_3$ 43.04, sum 100.07%. (2) West Chester county, New York; a typical dolomite not materially different from the Iowa rock. SiO_2 2.71, $Fe_2O_3+Al_2O_3$ 1.05, $CaCO_3$ 53.43, $MgCO_3$ 42.93, sum100. 12%. (3) Lockport, New York; Niag-

ara limestone. SiO_2 2.76, $Fe_2O_3 + Al_2O_3$ 1.42, $CaCO_3$ 51.85, $MgCO_3$ 43.94, sum 99.97%. This contains a sufficiently high per cent of $MgCO_3$ to class the rock as a fairly typical dolomite. (4) Milk-white crystals encrusting the foregoing specimen: SiO_2 0.18, $Fe_2O_3+Al_2O_3$ 1.21, $CaCO_3$ 81.62, $MgCO_3$ 17.15, sum 100.16%. This deviates widely from a true dolomite, as the Ca has quite largely replaced the Mg. (5) Betram, Iowa, between Mt. Vernon and Cedar Rapids. The rock is gray in color, with numerous light-colored crystals disseminated through it. Former analytical data seemed to indicate that the Mg content of the rock was in excess of the Ca, but the new work shows this to have been erroneous: SiO_2 0.90, $Fe_2O_3+Al_2O_3$ 0.90, $CaCO_3$ 55.61, $MgCO_3$ 42.58, sum 99.99%. The figures indicate a rather typical dolomite, as one would naturally expect from similar formations in the neighborhood. W. G. GAESSLER (*C. A.*)

38. The relation of structure to free alkali in sodium silicate solutions. WM. STERICKER. Mellen Inst. *Chem. Met. Eng.* **25,** 61–62(1921).—Ultramicroscopic exam. of sodium silicate solns. shows that they are 2-phase systems in which the disperse phase has a negative charge. This probably explains the discrepancies between detns. of the degree of hydrolysis by various methods. WM. STERICKER (*C. A.*)

39. Fluorspar and cryolite in 1920. HUBERT W. DAVIS. U. S. Geol. Survey, *Mineral Resources of U. S., 1920,* Part II, 65–80(preprint No. 9, published Sept. 1921). E. H. (*C. A.*)

Gypsum in 1920. RALPH W. STONE. U. S. Geol. Survey, *Mineral Resources of U. S., 1920,* Part II, 55–64(preprint No. 8, published Aug. 31, 1921). E. H. (*C. A.*)

PATENT

40. Decomposition of silicates. RITARÔ HIROTA. Japan 37,165, Sept. 25, 1920. Silicates, such as clay, feldspar, etc., are easily decomposed by heating with Na_2CO_3 or similar compd. and then treating with dil. H_2SO_4 or similar compd. *E. g.*, a mixt. of clay 100 parts and Na_2CO_3 70 is heated to dull redness for 1 hr., the product is heated with excess of 20% H_2SO_4 at about 100° during 1.5 hrs. K_2SO_4 and $Al_2(SO_4)_3$ thus produced are extd. with H_2O and pure SiO_2 remains in the residue, 95% of the clay is utilized. (*C. A.*)

Refractories and Furnaces

41. Report of the Refractory Materials Research Committee to the Institution of Gas Engineers. L. BRADSHAW AND W. EMERY. *Gas J.,* **155,** 157–60 (1921).—*Jointing materials for refractories. I. Softening point of mixtures of silica brick and clay firebrick.* Various mixts. of finely ground SiO_2 brick with fireclay brick were made into cones and the refractoriness was detd. The addition of a small amt. of fireclay to SiO_2 brick produces a greater effect than a corresponding amt. of SiO_2 brick added to fireclay brick. Thus the addition of 25% fireclay to SiO_2 brick reduces the refractoriness by $4^1/_2$ cones, and of about 43% by 6 cones, while the addition of these amts. of SiO_2 brick to

fireclay brick produces differences of 2 and 3 cones, resp. The eutectic mixt., which softens at Seger cone 19–20, has the compn. 15.01% Al_2O_3, 80.32% SiO_2, corresponding to 1 Al_2O_3 : 9 SiO_2. By submitting some of the same mixts. to a refractory test under load, it was found that the differences between the softening temps. with and without load are less in the case of siliceous mixts. than for those rich in fireclay (*C. A.*, **10**, 1782; **12**, 2118). When coarser-grained mixts. are used, the effect upon the softening point is less marked. *II. Mixtures of fireclay with fireclay grog.* The effects of mixing carefully graded amts. of grog and fireclay in the prepn. of mortars are discussed. Grog diminishes the shrinkage of the clay but also reduces the binding power and mechanical strength and makes the mixt. more difficult to spread. Coarse, medium and fine grades of clay and grog were formed into briquets for the measurement of contraction and resistance to crushing. The results are tabulated. The sharp increase in the contraction of the clay with diminishing grain size is clearly shown, as also the corresponding increase in mechanical strength, and the resistance to slag penetration. The addition of 50% of grog of the same grade largely reduces the contraction, and allows a greater penetration of slag. Differences of the same kind, but of less magnitude, are obtained by the use of only 33% of grog. Also a briquet of fine clay with coarse grog has a much greater contraction and crushing strength, and suffers less slag penetration in the mass than a mixt. of coarse clay with fine grog. Of the mixts. examnd., those composed of mixed grades of clay and grog appear to give the best results, being mechanically strong, with a sufficiently small contraction, and settling between bricks to a hard, compact mass, which is free from cracks and is not easily attacked by molten slags. By substituting ungraded building sand for grog, much inferior results were obtained. Study is being made of the beneficial effects that the addition of a small amt. of fine SiO_2 to mixts. of clay and grog would have. *Influence of oxidizing and reducing atmospheres on refractory materials. I. Behavior of clay pyroscopes and fireclay bricks in coal gas.* *C. A.*, **15**, 2972.

J. L. WILEY (*C. A.*)

42. Behavior of refractory materials under load at high temperature. K. ENDELL. *Stahl u. Eisen*, **41**, 6–9(1921).—See *Jour. Am. Ceram. Soc.*, **4**, 417, 1921.

43. The preparation of the dolomite-tar mixture in Thomas (basic converter) steel works. MAX BACKHEUER. *Stahl u. Eisen*, **41**, 954(1921).—The chem. and phys. properties of the dolomite have an important bearing on the life of the converter lining. Burnt dolomite with slight loss on ignition is best but the dolomite should not be sintered since this prevents the absorption of the tar. The mixt. for the converter walls should contain 35–40% powder, 30% fine and 30% coarse dolomite mixed with 8–10% of tar. The converter bottoms are made from a mixt. of 45–50% powder, 25% fine and 25% coarse dolomite with about 12% tar. R. S. DEAN (*C. A.*)

44. A method for the determination of the hardness of refractory materials at high temperature. E. RENGADE AND E. DESVIGNES. *Compt. rend.*, **173**,

134–37(1921).—Ludwick's modification of the Brinell test for hardness was applied to 8 clay bricks and 1 bauxite brick maintained at temps. varying from 1050° to 1490° in a graphite resistance furnace. Analyses of the compns. show that the Al_2O_3 content has small effect, but that the presence of alkalies causes considerable diminution in the hardness values. W. M. CLARK (*C. A.*)

45. Manufacture of fireproof materials and their use. ERNEST SCHRIEBER. *Feuerungstechnik*, **15**, 69–70(1921).—*Schamotte* is made by mixing together fireclay and quartz and burning the mass to a hard stone. Quartz-free schamotte contains clay and schamotte, while quartz-schamotte contains quartz also. Quartz-schamotte stone under 3% Al_2O_3 is considered acid. *Dinas stone* has a high SiO_2 content in the form of quartz. German Dinas stone is made by binding quartz with a refractory clay, and contains 84–90% SiO_2. English Dinas stone is made by binding quartz with CaO, and contains 97–98% SiO_2. The quartz must be calcined or the stones will swell. The mixts. are pressed together into forms, carefully dried and burned at 1500°F. Dinas stone is used in masonry which must withstand a very high temp. and is highly acid. In making MgO stone, $MgCO_3$ is burned, then ground, bound with tar and formed into shape. The mixt. is then burned at a very high temp. It is used in open-hearth furnaces, etc. Refractory bricks should not be set up with common clay but with a refractory mortar. For use with basic materials, a good mortar consists of 2 parts schamotte meal and one part plastic fireclay mixed with water to the proper consistency. For acid materials a mixt. of quartz meal and clay of high SiO_2 content is used. Refractory materials should not melt lower than Seger cone 26. Anything lower cannot be considered as a refractory. The best schamotte stone melts at 36 and the SiO_2 stone at 35. H. C. P. (*C. A.*)

46. The siliceous rocks considered from the viewpoint of manufacture of silica bricks. L. BERTRAND AND A. LANQUINE. *Bull. offic. direc. recherch. sci. ind.*, Nos. 1 and 2, **1919**, 21–27; *Rev. géol.*, **1**, 408–10(1920).—A discussion of the effect of the amt., nature, and mode of distribution of impurities in SiO_2 rocks on their use for making SiO_2 brick. E. T. WHERRY (*C. A.*)

47. Carborundum refractories in heat-treating furnaces. M. L. HARTMAN. *Trans. Am. Soc. Steel Treating*, **1**, 601–603(1921).—In addition to superior resistance at high temps., the elimination of extensive repairs compensates for a higher initial cost when carborundum is used. W. A. MUDGE (*C. A.*)

48. The question of the liquefaction of carbon. SIEGMAR MÜNCH. Wolfen. *Z. Elektrochem.*, **27**, 367–68(1921).—It has been found that graphite becomes plastic before reaching its m. p. With sufficiently high amperage small graphite rods can be melted through and welded together again. A description is given of an app. for melting large quantities of C.

H. JERMAIN CREIGHTON (*C. A.*)

49. Employment of aluminothermic corundum as a refractory product. ALBERT GRANGER. *Bull. official direction recherches sci. in. inventions*, **1921**, 297–300.—Crude corundum was pulverized, washed, treated with H_2SO_4, first cold then hot, until no further action was observed. It was then further treated with HCl and thoroughly washed with water. Several formulas are

given for prepg. mixts. to be fashioned into utensils for firing. Thus, corundum to pass a 150 sieve 8 parts, kaolin des Eyzies 1, argile de Berneçay 2. The mixt. is fashioned and fired. The product was found to withstand sudden changes in temp. and to bear the temp. of melted Pt without much fusion.

L. W. RIGGS (*C. A.*)

50. Laboratory type of electric furnaces. EZER GRIFFITHS. *Beama*, **9**, 12–18(1921).—An illus. review. G. broadly classifies elec. lab. furnaces as follows: (1) Wire or ribbon wound tubular furnaces; (2) graphite spiral furnaces; (3) C tube furnaces; (4) W and Ir tube furnaces; (5) zirconia and yttria tube furnaces; (6) granular resistor furnaces; (7) induction furnaces, low and high frequency types; (8) arc furnaces; (9) cathode ray furnaces.

C. G. F. (*C. A.*)

51. Electric heating furnaces in steel works. V. GUILLERMAN AND M. GILLOT. *Revue industrie minérale; J. four élec.*, **30**, 38–40(1921).—The use of *conducting-hearth furnaces* is a step towards insuring high quality steel. Conducting hearths are of two kinds: (1) the hearth with no resistance and (2) the resistance or heating hearth. In furnaces embodying the second type of conducting hearth heat is developed in the hearth by its own elec. resistance. This heat supplements the heat developed in the metal charge by reducing the amt. of heat given up by the charge to the hearth. The requirements to be met in constructing such a hearth are: (1) to obtain in the upper layers of the hearth enough elec. resistance and good thermal conductivity; (2) in the lower layers to obtain very low resistance and low thermal cond. From 10 to 15% of the total power used in a furnace may be expended in the hearth. In the construction of this hearth Cu bus bars are placed horizontally at the bottom of the furnace and bedded in a graphite and tar mixt. Above this the hearth is built up of a mixt. of magnesite or dolomite with graphite and soft Fe filings rammed into place with tar. The amt. of graphite and filings in the mixt. decreases as the hearth is built up and becomes *nil* at some distance from the surface. The cond. of the lower portion may be increased by embedding mild steel bars placed vertically with their lower ends in contact with the layer of graphite, their upper ends at a distance below the surface of the hearth depending on the resistance desired in the hearth. Such bottoms may last for 1000 heats on account of the variation in temp. during a heat being less in a furnace with this hearth than in an ordinary furnace; also, the high temp. of the surface of the hearth allows more satisfactory burning in of magnesite or dolomite patches.

LOUIS JORDAN (*C. A.*)

52. A new electric muffle oven for temperatures up to 1350°. H. SEIBERT. Berlin. *Chem.-Ztg.*, **45**, 772(1921); 3 cuts.—A brief description, without dimensions, of an oven made by H. Seibert & Co., Berlin, in which the resistor is nearly pure C so placed that the rectangular horizontal muffle is heated from 4 sides. It may be constructed for use with any kind of current, is easily repaired, and an oxidizing or reducing atm. may be held in the app.

J. H. MOORE (*C. A.*)

53. Researches with a flame of exceptionally high temperature. E. HAUSER AND E. RIE. *Sitz. Akad. Wiss. Wien*, Abt. IIa, **129**, 539–47(1920).—

A flame and burner are described by which it was found possible to reach a temp. of at least 3000°, the highest ever attained without the use of elec. energy. A liquid inflammable hydrocarbon is dispersed from the burner into a horizontal cone by H_2 gas. This cone is surrounded by an outer mantle of O_2 issuing from the outer part of the burner. The resultant flame is about 1 meter long, is luminous from incandescent colloidal C, and gives a continuous spectrum. If a rod of C is placed in the flame a layer of crystal graphite forms where the central hottest part of the flame has been in contact. If a porcelain plate is held in the flame a layer of soot or amorphous C is first deposited, but this is transformed to graphite when heated for a longer time in the hottest portion of the flame. This *graphite* possesses an unusual appearance. It consists of thin sharp platelets with a distinctly metallic cast on the side next to the porcelain, together with some small, transparent, strongly refracting crystals. On the other side the deposition is in fairly regular hexagonal figures similar in appearance to those resulting from the pptn. of colloidal graphite. Soot from camphor and wood charcoal both produce similar graphite in this flame. SiC_3 and carborundum are easily formed, and Zr, W, Mo and Cr melted. Excellent photomicrographs are given. The graphite was identified through its conversion to yellow graphitic oxide by the method of Staudenmaier (*Ber.*, **31,** 1481(1898); **32,** 1394 and 2824(1899)).

G. L. CLARK (*C. A.*)

54. Electric furnaces: Laboratory types. EZER GRIFFITHS. *Beama*, **9,** 145-50(1921); cf. *C. A.*, **15,** 3249.—A review. In this installment C resistor furnaces, the Arsem furnace and high (gas) pressure furnaces are dealt with in detail. Well illustrated. C. G. F. (*C. A.*)

55. The importance of air supply in combustion of coal. HENRY KREISINGER. *New Jersey Ceramist*, **1,** 39(1921).—A general discussion of the processes of the combustion and their control in the operation of hand fired furnaces. C. W. PARMELEE.

PATENT

56. Kiln and method of operating the same. LOIS M. UNDERWOOD. U. S. Reissue U. S. 15,186, Aug. 30, 1921. Original U. S. 1,337,298, April 20, 1920. In a kiln provided with a stationary furnace and a gas producer chamber, and a conduit forming a passageway from the chamber to the combustion chamber of the kiln, and an auxiliary air conduit through which additional air is supplied to the combustion chamber, and a portable grate including a series of hollow tilting bars with nozzles through which steam and air are injected into the bars, a series of tuyeres mounted on each bar and having air passages communicating with the interior of the bars, and an individual steam injecting nozzle extended into the nozzle of each of the bars.

BOOK

57. The Electric Furnace. J. N. PRING. London: Longmans, Green and Co. 485 pp. 32s. (*C. A.*)

Abrasives

PATENT

58. Apparatus for making carbides. J. H. REID. Can. 180,785, Dec. 4, 1917. Electrodes are placed in combination with means for feeding material to and between them and a support or hearth which retains material not fully converted within the zone of reaction until conversion is completed and which provides for the continuous flow of the converted product from the zone of reaction. Means are specified for varying the position of the zone of reaction with respect to the material in order that arcing may be prevented. (*C. A.*)

Whiteware and Porcelain

59. Glimpses of Ohio ceramic industries—II. CHESTER H. JONES. *Chem. Met. Eng.*, **25,** 619–22(1921).—A general description of methods and equipment used in the mfg. of tableware in the plant of the Crooksville China Company, at Crooksville, Ohio. H. F. S.

60. Physical and mechanical testing of porcelain insulators. O. BOUDOUARD. *Ceramique*, **26,** 79(1921); *Keram. Rundschau*, **29,** 496(1921).—Permeability, comp. strength and resistance to temp. changes were tested on porcelain insulator bodies. The test pieces in each case were cylindrical in shape having a diam. of 50 mm. and ht. of 5 mm. for the permeability tests, and a diam. of 30 mm. and ht. of 60 mm. for the comp. tests. Those used for studying the resistance to sudden temp. changes had a diam. of 100 mm. and heights of 5 mm., 15 mm., 25 mm., 35 mm., 45 mm. and 55 mm., respectively. The test pieces for permeability tests wree turned on a potter's wheel while the others were made dry press in a metal mold. The chem. analyses of the different bodies follow:

	1	2	3						
SiO_2	72.21	67.87	70.01	1.	RO	3.20	Al_2O_3	18.13	SiO_2
Al_2O_3	22.26	26.88	25.30	2.	RO	4.17	Al_2O_3	17.85	SiO_2
CaO	0.78	0.89	0.61	3.	RO	4.23	Al_2O_3	20.08	SiO_2
MgO	0.17	tr.	tr.						
K_2O	1.42	2.29	3.67						
Na_2O	2.38	1.50	0.49						

The permeability was measured by sealing the test pieces in a glass tube and noting the amt. of water which passed through. All test pieces tested were impervious to water. In testing the resistance to sudden temp. changes the specimens were placed in running water at 13°C for 15 mins. after which they were plunged into boiling water. This was repeated 3 times for each specimen. Bodies 1 and 2 withstood these tests well except that the 5 mm. pieces were somewhat warped. The test pieces showed many cracks.

		Compressive strengths.	Load in kgs.	kgs./cm.^{2}
1	7.07 cm.^{2}	14,250	8,500	11,000	1,591
2	.....	12,000	11,600	15,600	1,838

H. G. SCHURECHT

61. One solution of the porcelain insulator problem. E. E. F. CREIGHTON AND F. L. HUNT. *Elec. Rev.*, **79,** 17–20(1921); *J. Am. Inst. Elec. Eng.*, **40,** 480–82(1921).—Failure in cemented porcelain insulators is prevented by arresting the expansion of the cement used, through removal of the moisture when it is thoroughly set and preventing the moisture from re-entering it and causing repeated expansions. This is done by impregnating the cement after it has set with a pitch under vacuum and heat treatment. Small pieces so treated can be soaked in H_2O for days without showing absorption. Insulators thus prepd. have been installed on a 66,000-volt transmission line near the seashore for 3 years without a single failure occurring.

L. C. KRUEGER (*C. A.*)

62. Tests for laboratory porcelain. ANON. *J. Proc. Inst. Chem.*, **1920,** III, 210–14; *Analyst*, **45,** 397–98(1920).—The tests described are those adopted by the sub-committee on porcelain of the Glass Research Committee of the Inst. of Chemistry. (1) *Appearance, shape and weight.*—These should at least come up to that of the porcelain in former use. The wts. of vessels should not exceed pre-war av. wts. for articles of similar size. (2) *Tests for porosity of body and imperfections in glaze (dye test).*—A 0.5% soln. of eosin in water answers well. Some vessels are filled and broken pieces of others immersed in the sol. for 18 hours, after which they are rinsed, dried and examd. with a hand lens. Good porcelain shows no staining at all. If the articles fail under this "dye" test, it is extremely unlikely that they will stand the remaining tests. (3) *Resistance to heat and sudden changes of temperature.*—(*a*) The vessels are heated by direct application of Bunsen burners, and then lifted with small cold tongs onto cold pipeclay triangles to cool. This is repeated six times and the "dye" test again applied. (*b*) After thorough drying the same vessels are heated as before and cooled by being placed on cold metal (clean sheet lead). The "dye" test as before is then applied. (4) *Constancy of weight and resistance of glaze to high temperatures.*—(*a*) Vessels should suffer no loss of wt. after heating for several hrs. at a good red heat and should show no tendency to stick to pipe clay, silica or other supports. (*b*) The condition of the glaze should be noted after heating for 4 hrs. at 950°. No blistering or coaging should result. (5) *Cleaning test.*—Cleaned, ignited and weighed vessels should show no change in wt. after immersion for 12 hrs. in dil. acid followed by rinsing, wiping and ignition. Under this test, if the body is porous, liquid will have entered and on the application of sudden heat particles of glaze or porcelain will be thrown off by vapor generated from the imprisoned liquid, with resulting loss in wt. (6) *Resistance of glaze to acid and alkali.*—The loss in wt. sustained after prolonged treatment with boiling acid, Na_2CO_3 and NaOH should not exceed that found in comparison with high grade pre-war procelain. Two simple *tests for Pb* are finally given: (1) The porcelain is touched with HF, warmed, and the acid allowed to evap., followed by H_2S water faintly acidified with acid. (2) Fragments of the porcelain are heated to bright redness for 4 hours in a current of H_2. No darkening should ensue.

J. B. PATCH (*C. A.*)

63. Modern production of (porcelain) suspension insulators. E. H. FRITZ AND G. I. GILCHRIST. *J. Am. Inst. Elec. Eng.*, **40**, 470–79(1921).—A review of progress in making porcelain. The chief improvement is that the feldspar and flint, which were formerly mixed together with the clays in the blungers, are now first wet-ground in ball mills long enough to produce the necessary fineness. The higher dielec. and mechanical strength obtained more than counterbalances the cost to the extra operation. Care in filtering the slip produces filter cakes of such qualities as to eliminate the necessity of aging. CHARLES HECKER (*C. A.*)

PATENT

64. Baking porcelain insulators. MAGOEMON EZOE. Japan 37,166, Sept. 25, 1920. The procelain insulator is set in a round flat box and baked, the top of the insulator being completely covered with glaze. (*C. A.*)

BOOK

65. Chinesisches Porzellan. OTTO PELKA. Leipzig: H. Schmidt and C. Günther. M. 30. (*C. A.*)

See also No. 28.

Heavy Clay Products

66. Increase in strength of sand lime brick. W. DRAKEBUSCH. *Tonind. Ztg.*, **45**, 1170–71(1921).—The effect of aging on the strength of a no. of sand lime brick was investigated. The following limes were studied: 1. White lime with 90.12% $Ca(OH)_2$ and 0.95% SiO_2.; 2. Hydraulic lime with 73.05% $Ca(OH)_2$ and 19.65% SiO_2; 3. Hydraulic lime with 73. 88% $Ca(OH)_2$ and 15.55 % SiO_2; 4. Hydraulic lime with 88.40% $Ca(OH)_2$ and 5.52% SiO_2 and 5. Hydraulic lime with 74.28% $Ca(OH)_2$ and 12.78% SiO_2. The lime was dissolved in water and mixed with sand. The mixtures were allowed to stand 24 hrs. after which they were molded into test pieces and hardened in an autoclase by subjecting same to a pressure of 8 atms. for 9 hrs. The results are given below and show that the strength of sand lime brick increases upon aging and that hydraulic limes produce stronger brick than white limes.

6% lime	Compress. strength kg./cm.² 7 days	30 days	90 days	180 days	8% lime	Compress. strength kg./cm.² 7 days	30 days	90 days	180 days
				Stored dry					
1a	128	151	137	184	1b	152	166	181	205
2a	209	225	211	227	2b	244	280	302	330
3a	170	219	213	237	3b	153	200	236	261
4a	145	176	190	192	4b	142	173	219	216
5a	197	196	225	222	5b	211	206	238	241
				Stored wet					
1a	119	128	142	193	1b	130	158	146	012
2a	190	208	213	241	2b	239	272	291	303
3a	160	219	219	245	3b	150	170	232	309
4a	133	156	184	192	4b	119	148	191	194
5a	159	177	211	223	5b	103	165	242	242

H. G. SCHURECHT

67. A note on body cracking of terra cotta. E. C. HILL. *New Jersey Ceramist*, **1**, 70(1921).—The author concludes that fire cracking may not be due to variations in the firing temp.; that it seems possible to crack a body of almost any compn. by too rapid cooling; that a considerable range of compn. is possible in bodies without producing fire cracking, if the pieces are cooled slowly; dense bodies are more sensitive, therefore the use of grog of suitable size and quantity is advisable; the greater the amt. of sandy clays used the greater the contraction between 650° and 850°C; the most effective prevention is slow cooling at the lower temps. particularly from 650° to 500°C.

68. Some causes of the so-called disintegration of terra cotta brick, and allied ceramic material and suggested remedies. H. A. PLUSCH. *New Jersey Ceramist*, **1**, 65(1921).—Discussed under the following headings (1) High porosity of the body; (2) High silica content of the body; (3) The effect of sol. salts; (4) Poor workmanship; (5) Lack of mortar in joints and poor mortar; (6) Uneven thickness of ware; (7) Effect of the sun and frost; (8) Settlement of buildings. C. W. PARMELEE

69. Properties and tests of tiles. ANON. *Kalk-, Gips- u. Schamotte-Ztg.*, **27** (Nov. 21, 1920); *Chimie & industrie*, **6**, 206(1921).—There are as yet no official standards for tiles; and moreover their properties vary within very wide limits according to the method of manuf., *e. g.*, the crushing strength can vary from 25–250 kg., the lower values being found with hand-made tiles. Certain dealers and municipalities have adopted regulations varying according to the nature and shape of the tiles and covering the amt. of H_2O absorbed, tightness to water, content of noxious substances, apparent sp. gr., d., fragility, resistance to the action of frost, uniformity, and color. Certain of these properties can be easily gauged, while others require special tests carried out on the roof itself. A. P.-C. (*C. A.*)

70. Manufacture of gas-clinker brick at the Wurzburg gas plant. F. GREINEDER. *Gas. u. Wasserfach*, **64**, 245–47(1921).—Bricks suitable for building purposes are being made from the clinker from the gas retorts and generators. The plant has sufficient assorted clinker to make 1,150,000 bricks yearly. For making 1000 bricks there is required 4.5 cu. m. of ground clinker, 0.5 cu. m. of cement, 0.8 cu. m. of water. The total cost per 1000 bricks, including depreciation and interest charges, is 437.19 marks. About 7.5% is being realized on the investment. J. L. WILEY (*C. A.*)

71. The artificial drying of bricks. F. SCHOLZ. *Kalk-, Gips- u. Schamotte-Ztg.* **27**, Nos. 3 and 4(Feb. 27 and 21, 1920); *Chimie & industrie*, **5**, 559(1921).—Review of the various sources of heat used for the drying of bricks: exhaust steam, heat lost by radiation from the kilns, heat lost from the kilns in the cooling chambers, flue gases from the kilns and from the boilers.

A. P.-C. (*C. A.*)

72. The utilization of slag: The manufacture of slag building bricks. H. KOCH. *Industriebau*, **12**, 23–27(1921); 13 illus.—Detailed account of the Elberfeld plant. Relative costs for 1 cu. m. of wall: Ordinary clay or red brick requires 114 kg. coal in the course of manuf.; slag brick with Portland

cement binder, 64 kg. coal; slag brick with blast furnace cement binder, 33 kg. coal. C. G. F. (*C. A.*)

73. The equipment and operation of Brooklyn Crozite brick plant. ANON. *Concrete*, **18,** 74–78(1921).—This plant is of special interest as a products manufacturing achievement in the elimination of manual labor. Its working capacity is 100,000 concrete brick per 8-hr. day. In recent tests concrete brick show a remarkable superiority over clay brick, as well as an unusually uniform quality. F. H. HOTCHKISS (*C. A.*)

PATENTS

74. Bricks; pottery. C. W. WALLACE. Brit. 162,483, March 11, 1920. Bricks, pottery, and artificial stone products are obtained from clayey material, *e. g.*, as the white clayey material found near Molo in British East Africa, by introducing pressed, turned, or otherwise shaped, or unshaped pieces of the clay directly into the flames of a furnace, heating throughout, and effecting sudden cooling by plunging into H_2O, etc. (*C. A.*)

75. Furnace for manufacturing tile. TÔDA MOROTA. Japan 37,173, Sept. 28, 1920. The furnace has 2 doors opposite each other. Flames are conducted to the top of the furnace, then to the inner part through shelves on which tiles are placed. (*C. A.*)

Glass

76. Graded seal for joining Pyrex to lead glass. W. C. TAYLOR AND AUSTIN BAILEY. App. Div. Corning Glass Works, Corning, N. Y. *J. Ind. Eng. Chem.*, **13,** 1158(1921).—A seal consisting of five glasses intermediate between Pyrex and lead glass has been developed. All of the intermediate glasses are of a lead-free borosilicate compn., and are comparatively stable and can be worked repeatedly without devitrification. ED.

77. Tests for laboratory resistance glassware. ANON. *J. Proc. Inst. Chem.*, **1920,** Part III, 202–10(1920); *Analyst*, **45,** 396–97(1920).—The Glass Research Committee of the Inst. of Chemistry use the following tests to ascertain whether or not lab. glassware may safely be considered as resistance glass: (1) *Preliminary treatment.*—Cleaning with boiling water followed by 5% acetic acid. (2) *Treatment in autoclave.*—This affords a rapid sorting test for resistance glass. The glass vessel, filled with distd. water, is heated for 3 hrs. in an autoclave at a registered pressure of 4 atms. Any matter dissolved is then estd. by drying a portion of the soln. for 1 hr. at 120°, followed by ignition (not above 650°) for 3 min. The result is expressed as mg. residue per sq. dm. The alkalinity of the rest of the water is detd. by titration with methyl orange as indicator. Results are expressed as cc. 0.01*N* H_2SO_4 per sq. dm. Residue must not exceed 4 mg. per sq. dm. Alkalinity should not require more than 5 cc. 0.01*N* H_2SO_4 per sq. dm. The glass must not flake nor peel. (3) *Treatment with reagents.*—HCl (sp. gr. 1.15) is boiled for $\frac{1}{2}$ hr. in the vessel to be tested, the whole being kept in an air bath at 140°. This is repeated 3 times (each time with fresh acid), and finally the dissolved residue is dried down with a little $(NH_4)_2CO_3$, ignited and weighed. SiO

and Zn are both to be tested for in the residue; after the acid treatment the same vessel is tested by boiling in it 0.5 *N* NH_4Cl and NH_4OH, the dissolved matter, if any, being detd. as before; all results are expressed as mg. per sq. dm. Finally 0.5*N* NaOH is employed, the residue being tested for Zn and Pb. Residue from HCl test must not exceed 2 mg. per sq. dm., and that from NH_4Cl and NH_4OH test 1.5 mg. per sq. dm. (4) *Heat tests.*—Alternative methods. (*a*) The flask or beaker is heated in an air oven to 120° for $^1/_2$ hr., and then instantly immersed in cold water. (*b*) The vessel is filled with soft paraffin wax and heated to about 155° and plunged in cold water; this is repeated at increasing temps. (25° intervals) until it breaks. Good quality vessels will stand this treatment up to 200°. (*c*) A soln. of $CaCl_2$ (sp. gr. 1.33) is boiled in the vessel for 5 min. and the whole then plunged into water at 0°. (*d*) Another vessel full of water at 0° is plunged into boiling water. Vessels should not crack when submitted to tests under (*a*), (*c*) and (*d*). (5) *Tests for As and Sb.*—Full accounts of testing for these elements are given, with a diagram of the app. for distn. (6) *Annealing.*—The vessels are examd. under polarized light to detect internal stresses. J. B. PATCH (*C. A.*)

78. Plate glass manufacture. *Glassworker,* **41,** No. 10, 1, Dec. 3(1921); from *Ford News* of Nov. 15, 1921.—The Ford Co. announces a new method of making plate glass for windshields. The batch is melted in a 355 ton tank and flows from this onto a moving sectional cast iron table which travels under a stationary roller adjusted to the desired thickness. Sheets are 24″ wide by $^3/_8$″ thick. The conveyor plates are cooled with soapy water. From the table the conveyor carries the glass through a 464 ft. leer in 2 $^2/_3$ hours. The continuous sheet is then cut and set on grinding tables each unit 90″ long and passes under 180 ft. of grinding machinery and then under the polishing machinery after being washed. The travel of the glass is continuous from start to finish. R. J. MONTGOMERY.

79. Carrying large plate glass sheets. J. W. CRUIKSHANK. *Glassworker,* **41,** No. 4, 11, Oct. 22(1921).—Large sheets 12 ft. by 20 ft. weighing 1400 lbs. required 16 men to carry by hand. In 1907 a clamp like an ice tongs was installed and this type with improvements is in use today. The present clamp will release and clamp glass automatically due to a simple spring arrangement. One clamp at the center of the top edge is enough and does not cause undue strain. Suction discs have been used to lift glass from the grinding tables to advantage. R. J. MONTGOMERY

80. The electrical properties of glass. J. R. CLARKE. *Beama,* **8,** 235–38 (1921).—A review including a bibliographical list of 38 references. C. makes a number of definite recommendations on the basis of his own experience and that of others. For glass line insulators, in addition to the elec. and mechanical properties, one has also to consider cost. This necessitates the manuf. from cheap materials, in a tank furnace, thus excluding the use of Pb. The surface leakage must be low and hence the resistance to chemical attack fairly high; the specific inductive capacity should be low, to reduce flashover and the dielec. strength fairly high to prevent penetration. The coeff. of ex-

pansion must be low and the glass should be well annealed. All these conditions indicate a glass of high SiO_2 content. A potash-lime glass with as high a SiO_2 content as possible would be best on the basis of present data. Further research is needed. For glass condensers, a Ba-borosilicate glass has so far proved to be most serviceable. C. G. F. (*C. A.*)

81. Glass blowing in scientific and industrial laboratories. H. VIGREUX. *Chimie & Industrie*, **6**, 160–68(1921).—Brief historical sketch of the development of glass blowing together with hints on glass blowing, the difficulties encountered by the beginner, and the method of overcoming them.

A. P.-C. (*C. A.*)

82. Standardization of chemical apparatus. FREYMUTH. Berlin. *Z. angew. Chem.*, **34**, Aufsatzteil, 357–59(1921); 3 cuts.—A standardization of glass app., made of a glass of minimum alkali content, would eliminate useless expenditure and save quantities of cork and rubber materials.

THEO. F. BUEHRER (*C. A.*)

PATENTS

83. Glass manufacture. T. C. MOORSHEAD. 10/9/19; Ill. Off. Jour. Pats. 9/7/21. Pp. 3946–48. Covers a multiple automatic glass press. Special feature is the gathering and placing of the gathering in the mold in an unchilled state. Five drawings. WM. M. CLARK

84. Glass Furnaces. W. G. CLARK. Prit. Pat. 163,995; Ill. Off. Jour. Pats. 7/20/21. Pp. 3024. An elec. heated delivery trough is used to facilitate starting up in the cold. Heating may be performed by either resistance units or passing alternating current through the glass. Illus. by sketch. WM. M. CLARK

85. Bait for glass-drawing machine and in the process of drawing glass. ARTHUR E. SPINASSE. U. S. Reissue. U. S. 151,143, July 5, 1921. Original U. S. 1,170,464, Feb. 1, 1916. A bait for drawing hollow glass or cylinders from molten glass comprising means for supplying distending air pressure thereto, and means for forming and lifting without adhesion a glass novel, the means being adapted to support the novel without producing rupturing strain thereon during the drawing operation.

86. Method and apparatus for making glass articles. CLYDE R. LOTT. U. S. 1,382,994, June 28, 1921. The combination of a blank mold and a finishing mold located side by side and each comprising sections hinged to swing horizontally to open the mold, the molds arranged so that each mold is opened at the side facing the other mold and automatic means to transfer a blank by a horizontal movement from the blank of the mold into the finishing mold. C. M. SAEGER, JR.

See also No. 28.

Cement, Lime and Plaster

87. Special high resistance Portland cements. K. ENDELL. *Zement*, 9, 25–28(1920); *Chimie & Industrie*, **5**, 317(1921).—E. gives the results obtained in the course of tests of special German and Austrian cements which had a

remarkably high strength at the end of 2 days, tensile 10 kg. and compressive 180 kg. [per sq. mm.—ABSTR.]. Such results are of no great practical importance. Müller Rüdersdorf, in the course of the testing of several hundred samples of com. cements, found the following values at the end of 28 days: 8% below 300 kg., 14% 300–50 kg., 26% 350–400 kg., 15% 400–50 kg., 22% 450–500 kg., and 15% 550–600 kg. The strength requirements at present in force are sufficient for all purposes. The production of special cements is easily obtained by adding more CaO, but this entails 2 drawbacks: getting too near the limit where expansion is liable to occur, and greater fuel consumption for burning. These are scarcely compensated by the possibility of removing the forms from the reinforced concrete work at the end of 2 days.

A. P.-C. (*C. A.*)

88. The behavior of cement mortars in sulfate-bearing waters. H. NITZCHE. *Zement*, **9**, 37–40, 50–53(1920); *Chimie & industrie*, **5**, 317(1921).—As a result of serious troubles encountered with concrete work carried out in the neighborhood of Frankfort, where there is a subterranean sheet of sulfate-bearing water, N. carried out numerous tests in which local contractors were interested. Two large tables give a summary of the results obtained on concretes having varying amts. of Portland cement and of slag cement immersed in pure and in sulfate-bearing waters during 1, 2, and 3 yrs. Numerous photographs are given of the test pieces thus treated. Cf. *C. A.*, **14**, 606.

A. P.-C. (*C. A.*)

89. Experiments with blast-furnace slag. H. BURCHARTZ. *Stahl u. Eisen*, **41**, 193–200(1921).—The following conclusions regarding the use of blast-furnace slag in *cement* are drawn. The resistance of reinforced concrete to sea water is dependent on the density of the cement. *Cement* from blast-furnace slag made in the following proportions, 1 pt. cement, 2 pts. fine slag, 3 pts. coarse gravel, is as good as silica cement. Cf. *C. A.*, **14**, 3143.

R. S. DEAN (*C. A.*)

90. The addition of trass to cement. C. PLATZMANN. *Zement*, **9**, 227–28 (1920); *Chimie & industrie*, **5**, 317(1921).—Tests carried out on mixts. of 1 part by wt. of cement, 0.5–1 part of trass, and 4, 6, 8, and 11 parts of gravel led to the following conclusions: trass may be added to the mixt. to economize cement, its physical and chem. properties being suitable for the purpose. Cement-trass-gravel concretes were stronger than cement-gravel concretes having the same cement content, owing to the fineness of the trass. From an economic point of view, concretes to which trass has been added are not more expensive than those which do not contain any. A. P.-C. (*C. A.*)

91. The relation of carbon dioxide and moisture to the setting time of cement S. L. MEYERS. *Concrete, Mill Section*, **18**, 128–30(1921).—M. states: CO_2 is readily absorbed by tricalcium aluminate. This absorption of CO_2 by the aluminate in Portland cement causes an acceleration of setting time. This acceleration of setting time is due to the positively charged aluminate in dispersion adsorbing the negatively charged carbon ion, resulting in coagulation after the cement is gaged with water. The effect of hydration alone is

to retard the set, but in combination with CO_2 hydration indirectly acts as an accelerant by aiding carbonation. J. C. WITT (*C. A.*)

92. Automatic machine tests setting time. C. R. HILL. *Concrete*, **18,** 126(1921).—A machine is described for automatically detg. the setting time of cements and plasters by means of Gillmore needles. The cement test pat is carried on a plate which moves in a horizontal plane at a speed which may be regulated to accommodate different classes of materials. The needles are lowered to the cement at frequent intervals by the action of a cam. J. C. WITT (*C. A.*)

93. Artificial paving blocks. J. KLINKMÜLLER. *Verh. Ver. Beförd. Gewerbfleiss.*, **3,** 69–96(1920); *Chimie & industrie*, **5,** 64(1921).—Review of the various materials proposed in Germany for the prepn. of paving blocks and of a series of patents relative to the use of cement or asphalt concretes, with or without reinforcing. A. P.-C. (*C. A.*)

94. Judging the quality of Portland cement. R. J. COLONY. *Trans. Am. Inst. Mining and Met. Eng.*, No. **1039** (Feb., 1921).—Chem., mech. and petrographic methods are suggested for detg. the quality of cement to supplement the standard tests. A long series of studies has shown that the 3 constituents that form the bulk of Port. cement (CaO, SiO_2, and Al_2O_3) exist as fixed components with definite chem. compn. and const. optical properties. With these 3 compds. forming apices of a triangle, a diagram is made and the percentages of the samples are plotted. About 50 analyses were plotted on the diagram and all but two fell within a restricted triangular area. The changes of the tricalcium silicate, tricalcium aluminate, tricalcium ferrite, beta calcium ortho silicate and gypsum when H_2O is added to cement are described briefly. Limiting ratios of cement based on a minimum silicate content are used as a check and cements having a lower ratio are regarded with suspicion. The results of tests and anaylses of 6 samples are shown. The use of the limiting ratios is a simple easy method of judging the quality of Port. cement when used in connection with the usual standard tests. Results obtained are so suggestive that further work is now in progress. C. N. W. (*C. A.*)

95. Relation between tensile and compressive strengths of cement mortars. J. R. DWYER. *Concrete, Mill Section*, **18,** 99–101(1921).—On the basis of a considerable no. of tests D. concludes: The *T-C* ratio varies greatly with differences in compressive strengths of Portland cement mortars, and also varies somewhat for difference in materials and proportions. The variation is greatest at comparatively low compressive strengths, and below about 1,500 lbs. for 2-in. cubes may be extremely misleading. It is evident from data presented herewith that the tensile test favors cements which are weak in compression, and gives little indication of their comparative compressive strengths. J. C. WITT (*C. A.*)

96. The analysis of fibro-cement. B. J. SMART AND P. C. PECOVER. *J. Soc. Chem. Ind.*, **40,** 185–6T(1921).—S. and P. det. the approx. % of cement in cement-asbestos mixts. by treating with 20% HCl and detg. the Ca in the

ext. The asbestos adsorbs some SiO_2; hence high results are obtained for the asbestos by direct weighing of the residue. The adsorbed SiO_2 can be extd. with "alkali." E. G. R. ARDAGH (*C. A.*)

97. The cement factory in Torda (Siebenburgen, Hungary). H. SZEKELY AND E. HAVAS. *Beton u. Eisen*, **20,** 41–3, 66–9, 87–90(1921).—Dimensioned drawings give many details. The thick slime process of Smidth & Co. is to be used. Limestone and argillaceous schist are the raw materials. Natural gas is the fuel. JAS. O. HANDY (*C. A.*)

98. Researches on the volume alteration of cement and cement mortars on setting; influence of water addition, the method of mixing and of the cement on the extent of the volume changes; the relation between the length of iron reinforcement and the setting of cement mortar; the rate of expansion and contraction of natural stone when wet and dried. OTTO GRAF. *Beton u. Eisen*, **20,** 72–4 (1921).—A continuation of an undated earlier article. Cf. *C. A.*, **8,** 811. JAS. O. HANDY (*C. A.*)

99. A critical review of the wet process for manufacture of Portland cement. RICHARD K. MEADE. *Concrete, Mill Section*, **18,** 77–85(1921).—A detailed analysis is given, based on considerable data, whether the wet or dry process is best for the manuf. of Portland cement from hard, dry, raw materials. F. H. HOTCHKISS (*C. A.*)

100. The effect of temperature on some of the properties of materials. F. C. LEA. *Engineering*, **110,** 293–98(1920).—The results of expts. conducted in a non-inductively wound elec. furnace are given. They are of special importance to the builder and engineer. The tests include the detn. of the Brinell number, breaking strength, elastic limit, yield point, modulus of elasticity, elongation and reduction of area at fracture of heat cement and reinforced concrete. The effects of varying the temp. gradient and of reheating are also shown. The results are given in curves and some photomicrographs of the treated materials are shown. P. D. V. MANNING (*C. A.*)

101. Determination of available lime in quicklime and hydrated lime. ALICE I. WHITSON. *Chem. Met. Eng.*, **25,** 740(1921).—Details of a modified Scaife method. H. F. S.

102. The slaking of lime. KOSMANN. *Verh. Ver. Beförd. Gewerbfleiss.* No. **5,** 61–65 (May, 1920); *Chimie & industrie*, **5,** 317(1921).—The paste resulting from the interaction of CaO and H_2O during slaking and from the transformation of the $Ca(OH)_2$ to the colloidal state is due to the formation of a gel of Ca tetrahydrate (64%) and of a sol. of lime water (36%) contg. 4.572% of CaO. A. P.-C. (*C. A.*)

103. Rotary kiln lime-burning plant. ANON. *Blast Furnace and Steel Plant*, **9,** 467–68(1921).—An illustrated description of the new plant of the Granite City Steel Works. E. H. (*C. A.*)

104. Fine art of lime burning. GEO. B. WOOD. *Chem. Met. Eng.*, **25,** 705(1921).—General description of methods and equipment used in burning lime in the new plant of the Rockland & Rockport Lime Corporation, Rockland, Me. H. F. S.

105. The cementing qualities of the calcium aluminates. P. H. BATES. *Bur. Stand. Tech. Paper*, **197.**—The four calcium aluminates, $3CaO.Al_2O_3$,$5CaO$, $3Al_2O_3$, $CaO.Al_2O_3$, and $3CaO.5Al_2O_3$, which are the only anhydrous compds. of lime and alumina, were prepared in a pure condition by heating together the proper propn. of the oxides. After microscopic examn. had shown that homogeneous compounds had been formed, the products were finely ground and their cementing qualities when gauged with water were determined. The two compds. higher in lime reacted very energetically with the evolution of much heat, acquiring practically instantaneous set. The two higher in alumina reacted with water more like Portland cement, but showed higher strength at early periods than the latter. These were then prepared in larger quantities and containing such impurities as silica, iron oxide, and magnesia. The two compds. $CaO.Al_2O_3$ and $3CaO.5Al_2O_3$ were burned in a 2 by 20 ft. rotary kiln, varying their compn. so that the silica, iron oxide, and magnesia reached limits of 17.38, 3.10, and 3.66 per cent, respectively, as maxima in a series of eight cements. The process of manuf. was entirely similar to that used in the prod. of Portland cement. The ground cements were used in making the usual small tension and compressive test pieces and 6 by 12 in. gravel concrete cylinders of 1 : 1.5 : 4.5 and 1 : 3 : 9 propns. The striking feature of the data obtained from testing these at different periods up to and including 3 yrs. was the very high 24-hr. strength. The rich concretes prepared from four of the cements developed in 24 hrs. strengths in excess of 2800 lb. per sq. in., and the lean concretes from two of the cements gave strengths beyond 1500 lb. at the same period. Consistent gain in strength was obtained up to 1 yr., when one of the cements in the rich concrete gave a strength of 8220 lbs. per sq. in. Test pieces stored in water tended to show retrogression in strength with age. This was also noted with test pieces stored in the damp closet, but to a much less degree. This action may be explained by the fact that the products of the hyd. of all the aluminates are a hydrated $3CaO.Al_2O_3$ and hydrated alumina (except in the case of the anhydrous $3CaO.Al_2O_3$, when no hyd. alumina is produced). This latter is the cementing agent in these products, and, being colloidal, it is very susceptible to moisture changes. Large amts. of moisture are taken up in the presence of the latter with consequent swelling of the colloid and reduction in strength. H. F. S.

106. Potash shales of Illinois. M. M. AUSTIN AND S. W. PARR. *J. Ind. Eng. Chem.*, **13,** 1144–46(1921).—(1) In at least two localities in Illinois, shales occur which contain 5 per cent or more of potash. (2) Shale outcropping in several places near Jonesboro, in Union County, which contains 5 per cent of potash would be suitable, so far as can be determined from its chem. compn. and physical character, for use in the manuf. of *Portland cement.* (3) By using this material in the manuf. of cement and by applying the known methods of potash recovery, a yield of 5.3 lbs. of potash per barrel of cement could be obtained. (4) The constitution of the southern Illinois shale is complex. The shale contains free oil, bituminous matter, pyrite, undecomposed potassium-bearing rock, feldspathic in character, and potassium-bearing material

of the nature of glauconite or greensand. (5) Shale from Dixon, Lee County, contains 5.8 per cent of potash, which is held for the most part in a more stable condition than that in the southern Illinois shale. ED.

PATENTS

107. Floor-coverings. M. ROBERTS. Brit. 162,514, Apr. 6, 1920. A jointless floor covering is made by mixing calcined magnesite with an equal wt. of sawdust, cork dust, or wood pulp moistened with $MgCl_2$ soln. adding 5–10% of French Chalk and $12^1/_2$% of coloring matter, and subsequently adding $MgCl_2$ soln. at 28° Bé. till the desired plasticity is obtained. The coloring matter may be omitted. According to the provisional specification, asbestos may also be used as an ingredient. (*C. A.*)

108. Portland cement and calcining kiln. JOHN NELSON. Can. 212,734, Aug. 2, 1921. (*C. A.*)

BOOK

109. Portland Cement. RICHARD K. MEADE. Its Composition, Raw Materials, Manufacture, Testing and Analysis. 2nd Ed., Easton, Pa.: The Chemical Publishing Co. 512 pp. $5.00. (*C. A.*)

See also No. 4.

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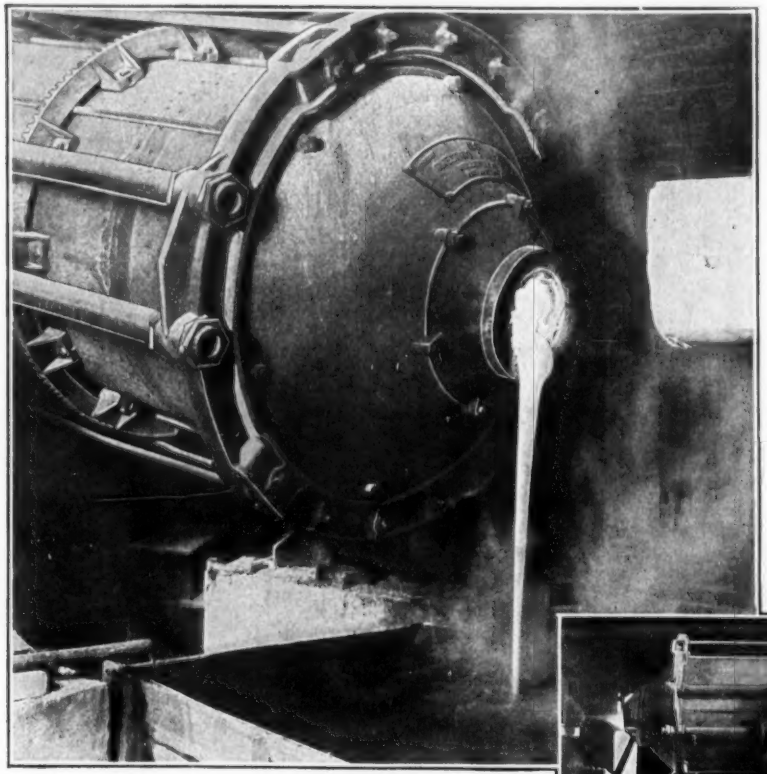

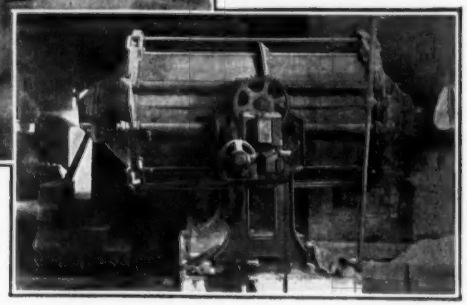

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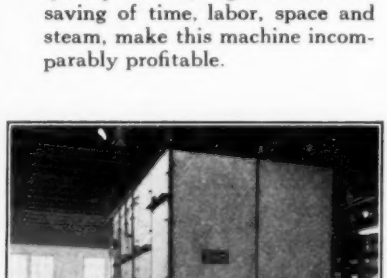

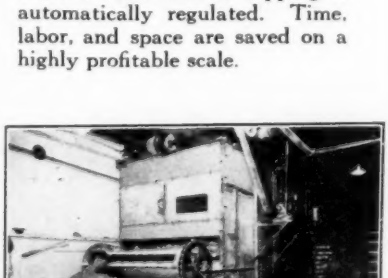

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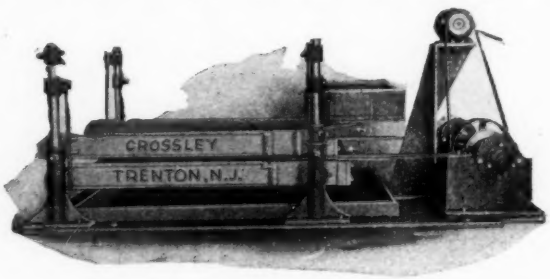

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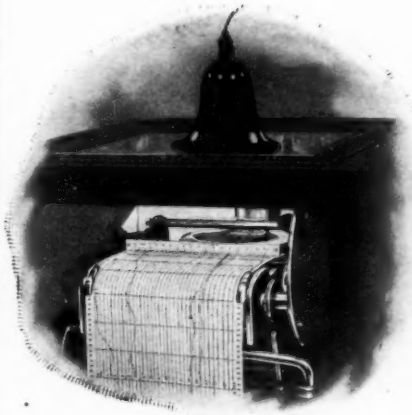

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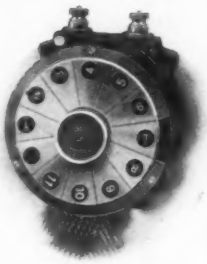

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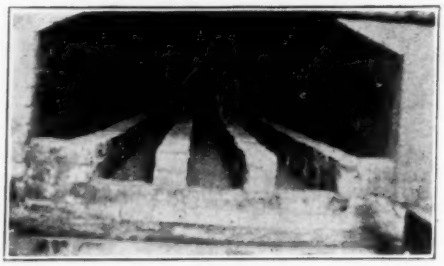

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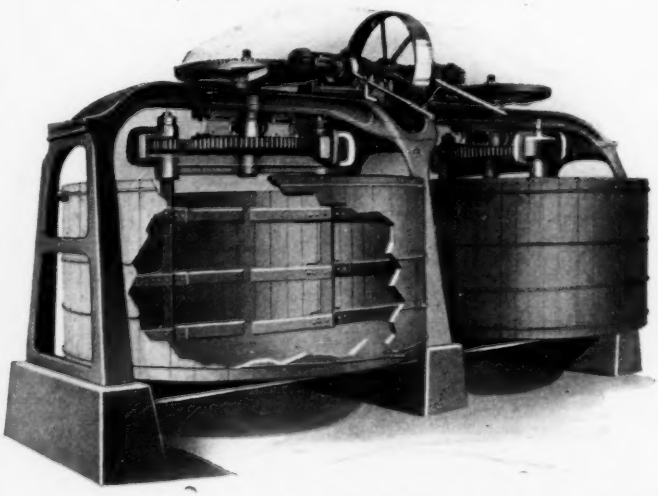

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